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SYNTHESIZED WORKSHOP PROCEEDINGS

JOSEPH R. POTVIN

Canadian Environmental Advisory Council

INDICATORS OF ECOLOGICALLY SUSTAINABLE DEVELOPMENT

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Canadian
Environmental
Advisory
Council

Indicators of Ecologically Sustainable Development: Synthesized Workshop Proceedings

Joseph R. Potvin

November 1991

Enquiries concerning the work of the Council and requests for Council publications should be addressed to:

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The Canadian Environmental Advisory Council

The Canadian Environmental Advisory Council (CEAC) is a body representing a cross-section of Canadians who are knowledgeable and concerned about the environment. It operates in a confidential advisory capacity to the Minister of the Environment. It provides the Minister with an alternative to the advice provided by the Department of the Environment and other federal agencies, and to the advice of specific interest groups. CEAC's public role, in terms of activities such as the publishing of reports, is therefore secondary to its primary function of advising the Minister of the Environment.

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Joseph R. Potvin is an independent consultant. In recent years he has worked for foreign, multilateral, federal, provincial, and territorial agencies, and non-governmental organizations. At the time of the workshop he was seconded on staff as an economist with the Canadian Environmental Advisory Council (CEAC) from his previous position with the Policy Directorate of Environment Canada. His work concentrates on the foundations, measurement, analysis, policy, and decision criteria of ecologically sustainable development economics. He received an Honours B.A. in economics from McGill University (1983) and an M. Phil. from Cambridge University, England (1986).

Canadian Environmental Advisory Council **Conseil consultatif canadien de l'environnement**

Ottawa, Canada
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November 14, 1991

The Honourable Jean Charest
Minister of the Environment
Ottawa (Canada)
K1A 0H3

Dear Mr. Charest:

I am pleased to submit for your consideration the enclosed Workshop Proceedings on Indicators of Ecologically Sustainable Development. The Proceedings resulted from a very challenging workshop hosted by the Council in July 1990. Many leading economists, ecologists and senior decision-makers devoted their time and intellectual energy to exploring the theories and practical issues underlying the subject of indicators. The Workshop was, in all ways, of the highest calibre, and the Proceedings represent the views of leading thinkers in Canada and the United States, including representatives of the United Nations and the World Bank.

The Council will publish several reports on the subject of sustainable development indicators as a result of our investigations and consultations. We hope that the Canadian public, and those who are actively involved in work on environment-economy integration, will find our research and analysis useful, and that we will be able to provide you with practical advice on future directions and initiatives.

Please accept our best regards and our commitment to further service on your behalf.

Sincerely,

Robert Page
Chairman

Canada

Acknowledgments

The author joins with CEAC in thanking each of the workshop participants for their enthusiastic collaborative spirit. In the months before the workshop we visited most of them, explained what was intended, and asked them what they wanted to learn from the others assembled. We are grateful for the time they generously committed before and during the workshop. Several also provided helpful advice as these proceedings were being written. Special thanks are due to the reference participants, Nancy Olewiler, Salah El Serafy, and Peter Bartelmus, and the authors of the delineation studies, Peter Victor, James Kay, and Jack Ruitenbeek, who undertook further responsibilities at the event.

The three facilitators, David Conklin, Erik Haites, and Rodger Schwass kept the entire workshop on time, on track, and in good form. The job of taking note of the race of ideas went to the rapporteurs, Michael Kelly, Brian Hull, Kenneth Ogilvie, Munir Sheikh, and Paul Rump. The workshop was not taped, but their draft reports were exhaustive, and this document synthesizes their accounts of discussions in their own groups.

CEAC members and staff, editors at B&B Editorial Consulting Ltd., and Manya Chadwick of the Canada Communication Group, provided detailed critiques of earlier drafts and in various other ways helped to carry the work through. We gratefully acknowledge the assistance of all.

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Preface

The Canadian Environmental Advisory Council (CEAC) began work on the subject of sustainable development indicators following the July 1989 meeting of leaders of the G7 summit nations. At this meeting, Prime Minister Brian Mulroney proposed that indicators should be prepared that link economics and the environment, and assess the compatibility of economic development and the protection of the environment, leading to sustainable development. The proposal was endorsed, and a recommendation was made that the Organization for Economic Cooperation and Development examine how selected environmental indicators could be developed, in the context of its work on integrating environmental and economic decision-making.

During the second half of 1989 and early 1990, CEAC reviewed studies and literature on economic and environmental indicators. Two important conclusions were reached. First, the most immediate target audience was identified as the senior policy-makers and economic analysts playing key roles in government, corporate, and development agency planning and decision-making processes. Second, since this target group relies heavily on economic analysis and resulting indicators, CEAC needed to examine how economic analysis systems could be broadened to incorporate sustaining environmental resources and life-support systems. CEAC's premise was that these indicators would be used in policy- and decision-making at the highest levels of government and industry.

Since both economics and sustaining the environment were involved, the search for indicators generated discussions with leading economists and ecologists in Canada. In addition, CEAC met with staff at the United Nations and the World Bank. These investigations led CEAC to the conclusion that the development and effective use of indicators depend largely on the economic, ecological, and political paradigms subscribed to by decision-makers. Integrating economic and environmental decision-making is complicated not only by incomplete knowledge and information, but also by different theories and assumptions of economics and ecology, as well as constraints imposed by decision-making processes.

To examine the complex issues relevant to indicators of sustainable development, CEAC decided to host a two-day workshop. CEAC invited leading representatives of various schools of thought in economics and ecology together with senior Canadian policy- and decision-makers to explore the question: **How do the conceptual foundations of economics and ecological analysis shape the indicators that will motivate policy in the 1990s?**

To stimulate discussions at the workshop, three delineation studies were commissioned. The first two describe the major alternative schools of thought in economics and ecology, and comment on how these schools propose to deal with the new sustainable development policy agenda through concepts such as 'natural capital' and 'ecological integrity'. The authors outline some of the implications for preparing indicators of ecologically sustainable development. The third study examines decision-making processes and the further complications that they introduce into the design and choice of indicators. This third study also contains an appendix that evaluates several economic analysis systems for their ability to incorporate environmental factors.

In July, 1990, close to 40 experts and senior decision-makers assembled at a workshop hosted by CEAC in Ottawa. Conceptual debates centred around the three delineation studies, while more practical discussions were held on taxation, measurement, and investment. Following these discussions, the participants identified five areas of particular significance and focused discussions were held on: regenerative capacity; pricing and taxation; ethics; worst-case scenarios; and natural capital.

The July workshop was an intellectually rigorous event that stretched the parameters and perspectives on sustainable development to their limits. The discussions were recorded in an extensive set of workshop proceedings prepared for the participants. In addition, CEAC decided to publish three documents under the general title of *Indicators of Ecologically Sustainable Development*:

1. Economic, Ecological, and Decision Theories
2. Synthesized Workshop Proceedings
3. Towards New Fundamentals

The first document contains the three delineation studies prepared as background papers for the workshop. The second document synthesizes the workshop proceedings, bringing

together the array of ideas and insights contributed by the participants. The third document is a distillation of the findings and sense of the workshop, as well as the work done by CEAC since July 1989 on indicators of ecologically sustainable development. It identifies five new fundamentals that should be reflected in the next generation of decision-support indicators. These fundamental principles significantly extend existing approaches to reporting environmental information, and they form part of the longer-term agenda for developing policy-relevant and operationally useful indicators.

CEAC's role in developing these indicators is first and foremost to advise the Canadian federal Minister of the Environment on the appropriate scope and direction of work in this area. While avoiding duplicating work on indicators being done by other groups, CEAC has benefited from the generous sharing of information by Environment Canada, Statistics Canada, and the National Round Table on the Environment and the Economy. The Council is not mandated to conduct ongoing research on a given subject. Hence, the three documents published represent a conceptual and, we hope, pragmatic contribution to the work being done by Canada and other nations on finding ways to integrate economic and environmental policy- and decision-making.

Author's Foreword

> *The Financial Times of Canada* completes an annual report card of economists' predictions for eight indices, from GNP to pretax profits. For the past decade, the *Times* reports, the country's top swamis have registered an average error rating of about 50%. Which means they're wrong just about as often as they're right.

I read this passage in the May 1991 *Report on Business* article "Gurus in Wonderland" the same Saturday I sat down to write this foreword. The article continued: "But besides good marketing, what do economic forecasters do really well? If you don't expect precision, most economists *are* pretty good at seeing where sets of assumptions lead." Many Canadians might have expected that advances in information and computer sciences would have led to a better record – so perhaps the practical problem facing forecasters has to do with the sets of assumptions they make about the dynamic systems they want to anticipate. In a general sense, this is what I interpreted to be the rationale for what CEAC wanted to explore in a workshop with senior economists, ecologists, and decision-makers: **How do the conceptual foundations of economic and ecological analysis shape the indicators that will motivate macroeconomic policy in the 1990s?**

Samuel Johnson once remarked that people "more often require to be reminded than informed." Digging deep into history, we may recall that in the early 1700s, ***oeikos*** and ***nomia*** were joined in the word "*œconomique*" by agricultural policy analysts led by Francois Quesnay (*Tableau Œconomique*, 1758) to refer to the *efficient management of community and habitat.* Economics subsequently became a profession. But even before the end of the 1800s, Alfred Marshall was decrying economists' neglect of environmental infrastructure, and felt compelled "to repeat that, whether in an old or a new country, a far-seeing statesman will feel greater responsibility to future generations when legislating as to land than as to other forms of wealth" (*Principles of Economics*, 1920: 661).

In 1946 John Hicks proposed "we ought to define . . . income as the maximum value [we] can consume during a week, and still expect to be as well off at the end of the week as [we were] at the beginning" (*Value and Capital*, 1946: 172). To bring this closer to the Brundtland Commission's wording (*Our Common Future*, 1987) we may say that generating income implies creating consumption possibilities for the present, without compromising the ability of future generations to meet at least a similar quality of consumption.

If income were something we could simply go out and observe, we would have the vital information necessary to gauge our performance. But Richard Stone, who received the 1984 Nobel Prize in Economics as one of the pioneers of modern economic statistics, national accounts, and input-output analytical systems, argued in 1951 that "to ascertain income, it is necessary to set up a theory from which income is derived as a concept by postulation and then associate this concept with a certain set of primary facts" (*The Role of Measurement in Economics*, 1951: 9). If the term 'economics' retains Quesnay's original connotation, economic theories are general principles by which we interpret information to determine our actions in relation to each other and to our surrounding ecosystems. Income is not itself a primary fact – a bit of *information* – but a theoretical construct to guide efficient management. It is information with a purpose, an *indicator.* CEAC convened this workshop to explore *'ESD indicators,'* meaning *information framed for the purpose of achieving ecologically sustainable development.*

How do the conceptual foundations of economic and ecological analysis shape the indicators? First, we wanted to discuss some alternative theories of ecology and of social decision-making, as well as the different ways economic theories conceptualize the environment. Then we wanted to inquire into general implications of these various ideas for practical economic analysis (economic accounts), policy (taxation), and decision-making (conservation investment).

This could have made for an over-packed day and a half, and it is a credit to the intellectual agility of each of the participants, facilitators, and rapporteurs that all the proposed topics were covered (and then some!). In writing this synthesis, I have been fortunate to work from extraordinarily rich notes and flipcharts. Several sections have benefited from follow-up contact with participants, and for clarification, occasional

explanations have been added. No additional literature research could be pursued at this stage.

While the content of this synthesis has been kept very close to that of the several rapporteurs' reports, the process of creating such a document involves employing one's own cognitive framework, subject comprehension, and whatever advice was available from specialists in the short time available. Every attempt has been made to stay 'true' to the sense of what participants said. I hope the result is recognizable to them, and useful to all those who – via their own alternative perceptions and purposes – are reasoning through the further development of ESD indicators, and examining where their assumptions lead.

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1 Introduction[1]

World View

The search for sustainable development indicators becomes focused only when we see ourselves as part of ecological systems. Ecologically sustainable development (ESD) indicators embody a revolution of thought, and reflect a remarkable increase in our understanding of how the world works.

The world community is becoming more connected over space and time. Societies are evolving and linking at a scale that affirms we are part of a single entity. This is evident in peoples' spatial scale perceptions and attitudes about the Earth. It is reason for optimism, because global thinking is an important step toward encouraging action. But this is not enough, because the *motivation* of sustainability is still fundamentally ethical: What will we leave for future generations in place of the resources we have consumed? What environmental and human treasures do we bequeath? These are questions of equity. ESD indicators presuppose an ethic.

The Information Challenge

The question, What is sustainable development?, must be asked according to some meaningful system of measurement and analysis that comes from our own evolving socioeconomic decision processes interacting with environmental change. Each local system is embedded in a larger system. The economy affects its dynamic environment, and the environment affects the dynamic economy. Consequently, a stable environment-economy system does not exist. All causes and effects ultimately seem to connect. So, what could we possibly expect to know about such a complex process? We must classify information; harmonize environmental measurements internationally according to common time and space scales; pursue more accurate and comprehensive physical measures; and define functional ideas about capital, income, wealth, equity, and value. Environmental effects are assessed, programs are evaluated, and national income accounts are supplemented. But the integration of so many diverse factors into clear and crisp summary indicators is limited. No 'one' indicator can suffice as a sustainable development yardstick, or as a measure of net ecological cost-effectiveness. Instead, we need an array of indicators serving different functions.

Sustainable development implies that something must be held constant and something must change. The question is: What do we want to hold constant and what do we want to change? The answer needs a solid theoretical base, yet it is complicated because the world is composed of complex systems that are neither totally predictable nor totally unpredictable. No wonder so many people complain that economics fails to deal with the real world. The challenge is to somehow account for the environmental effects of human behaviour.

It has been suggested that the most basic concepts and methods common to all paradigms of economic analysis are valid. The difficulty is determining boundaries within which they are relevant. Are natural resource inventories and ecological processes inside or outside the scope of economic analysis? To include them requires knowledge about ecosystem dynamics and constraints, and about the flexibility of socioeconomic systems to respect the conditions of ecosystem integrity.

Policy Relevance

Ecosystem science has become directly relevant to socioeconomic policy. We are just starting, however, to learn how to apply this new knowledge to our policies, and decisions. Clearly, various laws, policies, and initiatives at all levels of jurisdiction, and even federal and provincial budgets, should be reviewed and steps taken to ensure they consider induced changes to the environment. To report on human activity in the ecosystem, one must gather information; but stewardship further implies the responsibility to develop modes of social conduct compatible with ecosystem integrity (to inspire collaboration and to discourage transgression). Only in this context

[1]This introduction is based on workshop plenary discussions. The first three subsections synthesize points from the first evening session on 25 July 1990, when each participant was invited to make a one-minute opening statement regarding: ***What are some specific conceptual challenges we face in formulating the sustainable development indicators called for at the 1989 G7 Summit?*** The final section of this introduction is based on selected three-minute closing remarks from the afternoon of 27 July 1990, relating to communication between economists and ecologists.

can we devise a functional framework for indicators. Consequently, ESD indicators are value-laden, and will be used differently in different places. How this information relates to decision-making in various jurisdictions, political contexts, and cultures depends on fundamental axioms and assumptions peculiar to each, and the distinctive ways science is understood in decision processes.

ESD indicators necessarily relate to a global setting. But will decision-makers in the economies and ecosystems of Africa, Asia, and Latin America need to choose the same indicator sets that we consider most appropriate among the G7 countries? Probably not.

Dialogue Among Ecologists and Economists

An important occurrence in the policy field is that economists have started to demand information from ecologists. The economy is a subsystem of the ecosphere. It is an increasing part, and the first strategic questions must be: How big is the human subsystem? and How big should it be?

For increased knowledge about ecosystem dynamics to be useful in decision-making, a prime objective among economists and policy-makers should be to view ecosystem health as the logical corollary of socioeconomic health, and to determine standards, priorities, and constraints accordingly. When the reference manuals and tools for analysis of production, exchange, and consumption relationships become obsolete and counterproductive, better ones should be created.

Some economists have been working to get practical advice from ecologists about reasonable boundaries and conditions appropriate to ESD. But they have had difficulty using what they get. This is partly because they demand more precision and certainty than ecologists can possibly deliver. But also, the complexity, scepticism, and uncertainty typical of ecosystem science do not facilitate easy bridging across specializations. Moreover, few ecologists have systematically included a view of appropriate human behaviour in ecosystem analysis. A combined effort among ecologists and economists is urgently needed to formulate pragmatic indicators and rules of thumb that can overcome these severe limitations and provide policy-makers with specific advice. A general framework for ESD indicators must be simple, yet accommodate a range of subjects and a variety of scales. It must help integrated analysis without contaminating data of one kind or another with extraneous attributions.

Enough is known about ecosystem dynamics for economists to start making such knowledge an essential part of economic policy, and for ecologists to start making human activity an intrinsic part of ecosystem science.

2 Conceptual Foundations of ESD Indicators in Economic, Ecological, and Decision Theories[2]

Economics

Introduction

The paper used to motivate this discussion briefly surveyed five 'schools of thought' in economics for their respective representations of the ecosystem related to human activity. Workshop participants covered topics ranging from the conceptual basis of 'natural capital' to two fundamental debates of practical importance to decision-making. One debate was on the relationship between monetary values and environmental assets in the context of macroeconomic analysis; the other considered time and technological change.

Environment as Natural Capital

Most workshop participants felt that economic theory relating to manufactured capital offers useful insights when it includes environmental assets. The concept of natural capital encompasses two types: renewable and depletable. The main premise is that all capital should be "maintained intact."[3] One participant explained that "keeping natural capital intact" does not deny economic activity; instead, renewable capital (such as trees) may be sustainably exploited for human use if the resource is still able to regenerate itself. Depletable resources (like oil) should be treated as inventories, and used to generate returns exceeding the market value of inputs. Maintaining natural capital intact raises the question: To what extent is current economic growth based on exploitation of unrestored natural resources, rather than on value added through their various processing stages? Many contend we are simply living off a depleting supply of natural capital.

Some challenged that certain unique features of ecosystems do not fit within a 'capital' notion. For example, the 'waste sink' function of the natural environment does not appear to be correctly captured. Members questioned whether our use of environmental services can reasonably be viewed as capital inputs to production processes: manufactured capital can be expanded in response to market changes, but we cannot increase our environmental resource base. One person suggested that the broader services of nature must be distinguished from physical assets taken into human possession, and accounted for separately. Others doubted whether it would be possible to define a workable dividing line between environmental assets that fit into a physical capital concept and those that do not. Another argument was that the natural capital concept overemphasizes the input of human activity and underrates the effects of outputs, such as pollution, on the further availability of inputs.

Clearly, outputs affect future inputs when the environment is used as a waste sink in ways that inhibit the regenerative capacity of natural systems. Hence, it was argued, production functions that represent only combined inputs are misleading. Somehow we must link the outputs back to the inputs, completing the real-world cycle rather than appraising just one side of the process.

Monetary Measures of Value

Prices are supposed to measure relative value in an economy. Yet some economists at the workshop contended that the entire price structure is apt to be wrong when it is "seriously out of kilter with what is happening to the environment." If economic activity significantly changes the environment within which it occurs, and prices do not

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[2]The delineation study for this round was "Indicators of Sustainable Development: Some Lessons from Capital Theory," Peter A. Victor. In *Economic, Ecological, and Decision Theories: Indicators of Ecologically Sustainable Development*, Ottawa: CEAC. 1991.

[3]A.C. Pigou explains: "In a rough general way, the concept of 'maintaining capital intact' is easy to grasp. Capital consists at any given moment of a definite inventory of physical things. What these are depends in part on how the general interplay of demand and supply has worked in the past. But at any given moment they are constituted by an unambiguous physical collection. In order that capital may be kept intact, if any object embraced in this collection becomes worn out or is thrown out (scrapped), it must be replaced by 'equivalent' objects. When we have got hold of this notion we are able to develop a correlative notion, net real income. From the joint work of the whole mass of productive factors there comes an (annual) in-flowing stream of output. This is gross real income. When what is required to maintain capital intact is subtracted from this there is left net real income. This is Marshall's way of approach." (Pigou, A.C. 1986. Maintaining Capital Intact. In: Hamouda, O. (ed.) *Controversies in Political Economy*. New York: NY University Press p. 135.)

adjust to reflect those changes, then relative prices in the market become erroneous indicators of relative value. Actual relative buying and selling prices influence the daily microeconomic decisions of households, entrepreneurs, and governments. But under these conditions, relative market prices would not be attuned to peoples' goals regarding the ecosphere.

Some participants emphasized the importance of distinguishing between the micro and macro issues in measurement and valuation. One person proposed that each independent policy aim needs a corresponding instrument to operate in its pursuit. So, for national and global aspirations that are over and above numerous individual market decisions, society needs information appropriate to macroeconomic analysis and instruments. Accordingly, some suggested that actual market prices should be re-assessed according to resource and environmental changes and constraints, and expressed in terms of 'implicit' or 'shadow' prices.[4] Valuation problems can be tackled in many ways. However, economists are energetically debating whether reliable numbers can be generated that can or should be used to modify actual price information to determine adjusted economic indicators. Some argued that translating environmental and resource factors into artificial monetary valuations may be useful if adjusted economic indicators help us make better decisions. If the 'translation' problems are overcome, communication is improved. Other participants cautioned that the distinction between actual values and hypothetical values must always be maintained; numbers representing different types of information cannot be added together. And others maintained it is simply not useful to reckon hypothetical monetary prices for environmental assets and services or for environmental qualities that do not reflect realistic exchanges, or when close substitutes are not exchanged. Instead, environmental and economic issues should be described in their own vernacular through separate indicators, and greater effort should be made to familiarize the public and policy-makers with the explicit trade-offs.

Economic theorists have long faced the problem of assessing the monetary value of capital. Manufactured capital stock is accumulated through *past* expenditure, yet it derives its value from its potential productive abilities in the *future*. Economists have come to several working solutions by which aggregate physical capital is defined and assessed in monetary terms, but the issue has never been resolved to general satisfaction. This problem presents even more difficulty in regard to 'natural capital'. Sophisticated methods have been developed for imputing monetary values to 'environmental capital'. But some participants felt that expressing environment in terms of money imposes the values of the subsystem on the total system. They proposed, instead, that the values of the total system should be applied to the subsystem; this could be done by determining biophysical constraints, and letting prices set themselves accordingly. We might regard the Edgeworth Box portrayal of social distribution possibilities (Ruitenbeek, 1991) as part of a bigger box illustrating distribution within the total ecological community.

Time, Technology, and Ecosystem Dynamics

Participants in each working group explored the significance of technological change from several angles. One discussion evolved from an exchange about the renewal properties of ecosystems, and the search for analogies in economics. A natural scientist explained that ecological systems are organized around a few controlling variables. Each system has a particular spatial scale, unique regulatory properties, and a different material/energy cycling rate, sometimes extending over an extremely long time. Ecologists study what happens as an ecosystem transforms from one state to another. Whether or not it arrives at and lingers about a stable state depends on the renewal properties of the ecosystem in relation to its changing environment. Any organic system has to be 'exercised', or put to use by its myriad component life forms; it cannot be preserved without change. For example, a mature forest is not

[4] 'Shadow' (or social) pricing has been applied systematically during the last two decades in the field of *benefit-cost analysis*, to account for the consequences of a project on a country's alternative economic opportunities, balance of payments, income distribution, and other concerns. But this accounts only in a limited way for impacts on resources and environmental quality. Opportunity cost is the fundamental notion on which shadow pricing is based. However, in practice, there are many competing approaches, giving rise to extensive theoretical, methodological, and applications literature over the last two decades. The OECD, United Nations, and the World Bank have each published textbooks on this subject for project assessment, and several countries have developed extensive statistical frameworks to estimate shadow prices. In general, environmental resources and functions have been either not considered at all or given very cursory attention.

a static entity, but a dynamic and complex balance between growth and decay. If a key factor or condition is interrupted, the forest might not sustain its rate of rejuvenation, and might deteriorate on its own before the situation is corrected. Thus, an important measure in ecological analysis is *the length of time within which a key component must be reinstated* to sustain the integrity of a system. For variables that fluctuate over long cycles, the system can absorb a lot of disruption. For those on shorter cycles, the vital components must be reinstated quickly.

The natural scientist asked the economists around the table: "Is there an analogy to ecological renewal in economic analysis? What are the properties that govern renewal processes in an economic system? The closest analogy I can come to in an economic system is accessible and useable knowledge, and, in society, social trust."

Several participants agreed that what we see in the economy is renewal through technological change. One economist proposed that one of the major factors dividing peoples' economic policy positions is their assessment of the potential for technological change in relation to the time dimension of resource and environmental change. "Copper is now being replaced by glass fibre, which is cheaper and more plentiful." Some economists propose that technological renewal can be *infinite*. Hence, one participant asked: "Do we really care if we use up the total supply of copper?" Others argued that technological renewal through substitutability among inputs and technologies does, within limits, increase with time, but it cannot be *infinitely fast*. Thus, one fundamental difference in attitudes concerns the role of *time*. Given a long enough timeframe, the entire capital stock in an economy will be renewed with different technologies. It was further noted that time is the only distinctive feature between fixed and variable capital – all manufactured capital is ultimately variable.

Time is critical to assessing ecological disturbances caused by economic activity. The message in this discussion was that one should therefore weigh *the length of time within which key ecosystem components must be reinstated*, compared with *the length of time a socioeconomic system is expected to take to develop accessible and useable knowledge* enabling it to refrain from further environmental disruption and encourage ecosystem recovery. If appropriate technological change is not generated or implemented quickly enough, then the capacity for ecosystem renewal degenerates, and the capacity of potential technological renewal to mitigate the damage becomes a question of mere academic interest.

Does Manufactured Capital Substitute or Complement Natural Resources?

Economists at the workshop differed markedly on this question. Some participants felt that the potential and challenge of technological change were more important than whether manufactured capital *substitutes for* or *complements* natural resources. The fundamental issue is based on differences among economists about whether *substitutability* engendered by technological change can save humanity despite an otherwise deteriorating ecosystem.

The Substitutability Argument

Some economists at the workshop considered manufactured, natural, and human forms of capital to be very 'malleable' – each is readily *substitutable* from one application to another. They stressed that technological progress is the *substitution* of one factor for another to increase economic efficiency. The sustainability of development can be extended dramatically by technological change through such breakthroughs as the switch from brass to iron, nickel to ceramics, or copper to glass fibre. Generally, they maintained that natural capital and manufactured capital are *substitutable*, and human ingenuity can improve factor *substitutability*. But a practical question is: *How substitutable* are individual components in particular circumstances, given both the technical possibilities and price signals in the marketplace?

It was suggested that further study is needed to distinguish strong and weak marginal substitutability between specific environmental factors and manufactured capital. It would be especially useful for policy purposes if economists could predict the technical/economic switching points (a participant referred to 'substitution thresholds') at which one type of capital, or alternative options within each type, can be expected to become most economical. It was pointed out, however, that because technological change is difficult or impossible to measure, such summary indicators are unlikely.

Excerpt from a workshop discussion:

"If you take the view that man-made capital and natural capital are complementary, then you must ask: 'Which is the limiting factor to growth?' We have moved from the days when the constraint was man-made capital to today when it is natural capital."

Excerpt from a workshop discussion:

"It almost pays to be a technological pessimist. If you are an optimist you think you can use up your resources now because substitutes will be found."

"You mean you have to be a pessimist to fulfil the expectations of the optimist?!"

The point was made that the concept of substitutability among natural, manufactured, and human capital must include a common procedure for valuing their respective inputs, as well as for estimating relative changes in these values. Technological choice responds to the evolution of human know-how, shifts in social dynamics, and the supply and demand for alternative resources. However, it is widely accepted that market prices under current precepts do not properly account for effects on ecological integrity. Thus, it is questionable to what extent prices can be relied on to induce ecologically sound technological substitution. (A participant noted that market forces frequently press in the opposite direction. For example, the oil crises of the early 1980s stimulated a shift from the use of oil to coal in many parts of the world. Price signals did not reflect the negative environmental impacts of increased emissions of SO_2 from coal which lead to acid rain.)

In response, some participants suggested that if we do 'get the prices right' by *internalizing environmental externalities*, then the appropriate factor substitutions may materialize. To do this, someone added, we must first "get the physical constraints of natural capital right." Then, by establishing a policy framework and specific measures to incorporate such criteria and boundaries into the price system, market prices may support the sustainable use of natural resources.

The Complementarity Argument

Another group of economists maintained that manufactured capital can only be considered *complementary* to natural capital – it is not a *substitute*. Their argument was that manufactured capital and labour are agents of transformation in a flow-through biophysical process, whereby raw materials and energy are acquired from the environment, used for human wants, degraded, and returned to the environment. In this process, manufactured capital is the product of labour applied to natural resources. Thus, the relationship between natural resources, capital, and labour can only be complementary. (One participant proposed 'dependent' as a more appropriate term.)

Substitution among technologies applying different combinations of resources may be just another way of saying technological change. Technological *ingenuity* has no bounds since human know-how builds upon itself and is a renewable resource. But since manufactured and natural capital are complementary, technological possibilities are limited by the amounts of resources available, the laws of physics and chemistry, and the principles of ecology. Thus, it must be acknowledged that, within relevant time scales, there are absolute limits to stocks of depletable resources like copper or crude oil, and fairly strict limits on *sustainable rates of flow* of renewable resources like fish, wood, and corn. Moreover, several features of our environment, such as the atmospheric ozone layer, *have no substitutes*. Hence, incontrovertible constraints exist on the scale and rate of expansion of human activity, which technological substitution cannot overcome.

It does not necessarily follow that there are necessary limits to 'income possibilities'. Some participants noted that technological change can still increase the human benefits derived per physical unit of resource throughput. Thus, *sustainable development* is feasible, while complementary depletable resources are used up, if net advantages are secured. Practical experience demonstrates that some technological innovations can generate more benefit per unit throughput and others can bring about net losses. Technological change has tended toward a rapid increase in absolute quantities of resource

throughput, a reduction in the regenerative capacity of renewable resources, and a shift from renewable to depletable resources. Some economists argued that although conventional economic indicators suggest growth, the rate of income generation per unit throughput (for example, kCal of available energy) has declined.[5]

[5]The precise definition of *income* is important in this statement. The term was used inconsistently among different participants during workshop discussions, but it has been a subject of intense debate among economists throughout the history of the discipline. Sir John Hicks stated in *Value and Capital* (1946: 172): "It would seem that we ought to define a man's income as the maximum value which he can consume during a week, and still expect to be as well off at the end of the week as he was at the beginning." He added, "If a person's receipts are derived from the exploitation of a wasting asset, liable to give out at a future date, we shall say that his receipts are in excess of his income." (1946: 187) The 1991 *System of National Accounts*, to be published by the United Nations Statistical Office, will define income as "the maximum amount that can be consumed in a period while maintaining initial capital and net capital transfers received in that period intact." **The application of this definition of income differs significantly, depending on whether 'capital' includes or excludes natural resources.** The 1991 *System of National Accounts* will include both of these options, and a 'best' approach is expected to be the outcome of subsequent years of experimental application among member countries. The above statement that "the rate of income generation per unit throughput . . . has declined [with the] shift from renewable to depletable resources" is consistent with the interpretation of the new economic accounting adjustments by Salah El Serafy, where capital includes environmental assets. ("The proper calculation of income from depletable natural resources." In: Ahmed, Y., El Serafy, S. and Lutz, E. (eds.) 1989. *Environmental Accounting for Sustainable Development*. Washington D.C.: the World Bank.)

Ecological Integrity[6]

Introduction

Participants deliberated questions of practical significance to both scientific knowledge and public decision-making, and ranged into the limits of current scientific perceptions about life. The background paper by Kay described several concepts relevant to ecological integrity and the types of indicators each would need if applied to environmental management policy.

The debate was very rich in ideas. An attempt is made in this section to set out some of the main differences as they arose both in the workshop and in several follow-up contacts with participants. Further discussions on indicators provided useful insight into alternative perspectives, communication needs, and data problems. Finally, some brief observations were made about how economists, ecologists, and decision-makers could improve their mutual understanding, as well as their dialogue with the public.

Alternative Policy Approaches to Human Involvement in Ecosystems[7]

Indicators are useful only in the context of appropriately framed questions. One reason for the continuing difficulty of developing a framework for ESD indicators is confusion or disagreement about what questions on ecosystems need to be answered in relation to policy. Three profoundly different policy orientations are discussed in detail below. Participants appeared to have two different interpretations of *ecosystem optimality*, although these distinctions were not always maintained. *Optimality* can refer to the state that is most *desirable*. However, Kay referred to an ecosystem's *optimum operating point* as a transient condition in multidimensional state space for which "the disorganizing forces of external environmental change and the organizing thermodynamic forces are balanced." This is the case, temporarily, in a *climax community*. The optimality notion, and its role in shaping environmental management policy, is a distinguishing feature of the three approaches that follow.

Steady-State Equilibrium

A well-established approach to environmental management views particular optimum ecosystem states as *desirable* targets. Using indicators based on a notion of steady-state equilibrium, the policy objective is to suppress disruptive cycles and periodic accidents, such as spruce budworm outbreaks or forest fires.

Several participants argued, however, that a climax community *per se* is a bad target for environmental management. In particular, where steady-state equilibrium targets are combined with the shrinking of mature wilderness ecosystems to isolated pockets, the resulting climax communities may lack the resilience during environmental fluctuations to maintain their cyclical self-regenerative capacity. Under these circumstances, the more extensive an artificially sheltered climax condition, the greater the risk of an 'accident' (discontinuity), and the more drastic the consequences when disruption occurs.

Dynamic Disequilibrium

The basic difference between dynamic analysis and static analysis might be described as follows. *Static analysis* compares each 'snapshot' study of an ecosystem with a desirable steady state, and policies are designed to minimize disequilibrium. In contrast, *dynamic analysis* requires several snapshot studies of a moving ecosystem separated by known time intervals. A management policy for human interaction with the ecosystem would involve an understanding of the dynamic disequilibrium transformations between the snapshots. Two different approaches to policy based on dynamic disequilibrium emerged from discussions. *Limits of sustainable disequilibrium* highlights the critical boundaries of sustainable

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[6]The delineation study for this round was "The Concept of Ecological Integrity, Alternative Theories of Ecology, and Implications for Decision-Support Indicators," James J. Kay. In *Economic, Ecological, and Decision Theories: Indicators of Ecologically Sustainable Development*, Ottawa: CEAC. 1991.

[7]This section synthesizes material from the rapporteurs' workshop notes, with several follow-up telephone conversations and meetings with participants. For clarity, some liberties have been taken. There is a particularly complicated disagreement about the meanings – or *nuances* – associated with terms like development and health. One gets the impression that ecological scientists agree on fundamental notions. The controversies are mostly about what role human beings ought to play, and what descriptive *terms* should be used. The terminological imbroglio is well known to those who have worked in community health or socioeconomic development and, not least, sustainable development.

disequilibrium. *Ecosystem development* looks at an ecosystem's potential self-organizing capacity.

Limits of Sustainable Disequilibrium. One approach focuses on how far an ecosystem can be pushed from a particular dynamic orientation before catastrophic change to a new thermodynamic path (an 'ecological flip') is likely to occur.[8] A connection was suggested between the description of catastrophe theory in Kay's paper and the *critical value sensitivity* method of decision analysis in Ruitenbeek's paper. This method determines: values for each parameter at which the decisions would change, given explicit quantitative decision rules; some capacity to predict alternative outcomes resulting from decisions; and, knowledge about preferences among those outcomes. The management question for which indicators would be sought is: How much misbehaviour can we get away with? This application of the stress-response analytical framework characterizes many new sustainable development policies and programs.

A counter-argument was presented that ecosystem thresholds and paths of future change are not well understood even for familiar ecosystems. It is seldom possible to know how much stress can be applied before human-administered shocks flip an ecosystem. Nor can we accurately predict the outcome of catastrophic change. We know the Great Lakes have 'flipped' into a new thermodynamic path, caused in part by eutrophication due to phosphates and other human wastes. This has led to a great relative deterioration of ecosystem integrity (even though conditions were created favouring the artificial development of a salmon fishery). Some would like to see the Great Lakes brought back to their original state, but there is no assurance that the system could be re-established on the original thermodynamic path, even if the original conditions were recreated. This might suggest the need to distinguish between *measures* of past and present ecosystem conditions, and *estimates* or *projections* to assist judgements on the future states of ecosystems.

Aside from the uncertainty associated with ecosystem dynamics, this approach also raises interpretation problems. One participant noted that if we consider the degree to which some ecosystems have become 'domesticated', the applicability of critical boundary notions appears to depend partially on whether the systems are 'free enough' to redirect themselves and flip into different states as a result of stress. For example, reducing a forest's genetic or species diversity can weaken its ability to endure or recover from natural environmental disruptions. At the same time, many systems – particularly those associated with agricultural activities – are artificially maintained with synthetic inputs and physical restructuring that influence the character and timing of possible flips to new thermodynamic paths. As a result, the baselines that might be used to guide human activity are themselves a function of human activity.[9]

Ecosystem Development. Another approach to human involvement in ecosystems is to proactively facilitate the *dynamic self-organizing capacity* of ecosystems. This development policy would aim for more effective use of energy and materials within ecosystems through longer, more thorough exchange and recycling networks. The implications of 'ecosystem development' spawned an extensive debate.

Can we say one ecosystem *is more developed* than another? This question was of great interest to the social scientists, but provoked considerable controversy among the natural scientists. Kay gave a qualified "yes," if one ecosystem *recycles matter more times through longer cycles* than another. An ecosystem would be more developed if it were structured for more effective use of energy and materials, as might be expected when it comprises more trophic levels. Two types of quantitative comparisons appeared in Kay's paper: A:B (the Baltic Sea and Chesapeake Bay) and A_1:A_2 (two similar and adjacent sites near Crystal River, Florida). The concept of relative development is proposed only for A_1:A_2 type comparisons, which examine two hitherto identical sites for which conditions begin to differ, or which track the same site through time.

Several ecologists emphasized that each ecosystem evolves within unique physical and historical

[8]Kay pointed out that, through time, ecological systems respond to the opportunities and stresses in their environment by: changing to new optimum operating points while continuing on the same thermodynamic path; changing to new optimum operating points via bifurcation points to new thermodynamic paths; or exceeding catastrophe thresholds whereupon the systems 'flip' to entirely different thermodynamic branches.

[9]One participant suggested that a possible indicator for managed ecosystems would be the yield per unit input of things that humans can use. If this yield is declining, then one could say that the productivity of the managed ecosystem may also be declining. Elsewhere, the point was raised that one way to interpret the circumstances under which a domesticated ecosystem is likely to flip is by determining when further artificial inputs become 'uneconomic' in the market system.

circumstances, leading to a particular set of complex dynamic processes, trends, cycles, and stages, along with random deviations. The characteristics of any ecosystem reflect its own cumulative environmental and evolutionary experience. Consequently, two ecosystems *cannot* be considered relatively more or less developed, healthy, or desirable *in terms of their own paths*. Most biologists reject the concept of development because, as one participant noted, biological science does not accept a *teleology*; that is, natural processes are considered to have no ultimate goals, directions, or purposes. But unlike biology, which examines individual species, ecosystem sciences investigate the community of interrelationships among living beings, including all aspects of human society, and between them and all the things, situations, qualities, and processes that surround them. Within this framework, the very human concept of ecosystem development involves conscious value judgements.

As intrinsic participants in ecosystems, human beings have found it worthwhile to distinguish between the desirable and pernicious influences of our activities. In particular, several economists found the idea of verifiable ecosystem development intriguing, in terms of integrating an ecosystem approach into economic analysis. Do we potentially have scientifically sound concepts of *ecodevelopment*? Do we know how to get positively involved in ecosystem development? As a society, we must define our ecosystem ethics and identify the biophysical processes that must be protected. Decision-makers need explicit criteria upon which to base judgements. If the future of an ecosystem were to be altered in one of two different ways, what would be good or bad? How would we move from analysis to actual behavioural change? Practitioners must grapple with these questions, and indicators are needed that aid judgement, if only because we use ecosystems in ways that allocate resources to human consumption under numerous objectives and constraints.

Measurement Perspectives

When disturbances to ecosystems are evaluated in *anthropocentric* terms, the evaluation criterion is whether, and to what extent, humans value the results. Yet anthropocentric can imply either the ***belief*** *that human beings are the most significant entity in the universe*, or simply the ***method*** *of interpreting the world in terms of human experiences*. While not directly considered in most discussions, this distinction is important. The *anthropocentric method* is often strictly applied as the corollary of an *anthropocentric belief system*. However, it can also be chosen for purely pragmatic reasons, in conjunction with what is broadly referred to as a *biocentric belief system*, by which human beings are common participants with other life forms in the ecosphere.

Several participants were concerned that when the anthropocentric method and belief system are adopted, the management indicators – and thus the management system applied – tend to be based on a component-by-component assessment of only those commodities that are of *obvious* and *direct* interest to humans. This leads to management aimed at maximizing the harvest of the few directly valuable species, and the usefulness of indicators is judged by that standard. The harvesting of one valuable fish species and its productivity over time are carefully measured. Water quality, stream flows, and lake levels may also be measured according to the needs of only that species. It always appears easier to measure and manage on a component-by-component basis, and administrators tend to do what is administratively easy. But this approach may hide the really important indicators of ecosystem health on which that 'one' species depends, leaving decision-makers without any basis for judging whether particular changes to an ecosystem are bad or good. A broad ecosystem approach evaluates phenomena according to the redistribution of benefits and burdens among all interdependent life forms.

Composite Indicators

One member suggested ecologists consider a method that has proved useful in economics. It involves developing a few common units of measurement and linking them spatially through geographic information systems (GISs). The key question became: Could ecologists aggregate several diverse ecological measures into some composite indicator that would show how close we are to the threshold of significant transformation of an ecosystem? Decision-makers would find such information very useful. However, several participants felt that summary indicators would be too simplistic and argued for the need to study ecology and human links directly and in detail. They argued instead that orthodox economists should change their way of thinking and try to understand ecosystems in their complexity. Economists should avoid the simple 'black boxes' that come with composite measures and indices. No doubt, scientists can quantify and make state-

Excerpts from a workshop exchange on ecosystem research in Canada.

Participant 1: "All problems are becoming ecosystem problems. The world goes on, and we are going to generate regulations that are ecosystem-oriented. So if you tell me we have work in progress, that will be a big step forward."

Participant 2: "In Canada there has been an extraordinary amount of public support for ecosystem research. But the Department of the Environment stopped funding this type of work. Nobody now goes to DOE for money for this purpose."

Participant 3: "The U.S. EPA is again focusing on environmental research, but it may not now have the funds to undertake research on ecological diversity."

Participant 4: "Today if you do ecosystem research, you do it out of your own pocket."

Participant 5: "Why is there so much resistance to ecosystem research?"

Participant 2: "Reductionist science doesn't understand the more eclectic approach."

Participant 6: "Yet understanding ecosystems seems to me to be more important and useful."

ments about macro-level ecosystem changes, but composite or aggregate ecosystem indices were not viewed as appropriate.

All agreed that detailed indicators are very useful because they disclose stress points and specific ecological thresholds. But it was also generally agreed that scientists cannot successfully communicate masses of information on microstudies to the public or to policy-makers. Too much detail does not help people who need to draw general conclusions. Thus, while reducing the complexities of ecosystem dynamics to a few indicators has problems, several participants proposed that there are clear aggregate effects on multistressed ecosystems, and scientists should still try to pragmatically arrive at some core indicators of ecosystem change. In principle, someone suggested that at least two kinds of macro-level information about ecosystems would be immediately useful in decision-making: *constraints* (What are the significant thresholds before ecosystems undergo fundamental change?) and *directions of change* (What are the likely or potential net outcomes of alternative combinations of human activities?).

Information Problems

It was suggested that knowledge of the effects of human activity on the environment must be communicated in a 'feedback loop' so that further human action can be guided by experience. People may need to know how much forest land has not been restocked, and hence has not regained appropriate characteristics. They may need to know that agricultural yields are expanding because of the increased use of fertilizer, but that yields per unit of fertilizer applied are decreasing with ecological, financial, and social implications. Various environmental decisions now crowd the agenda, but current information is inadequate. Participants identified several obstacles to a proper flow of information.

Economic Reductionism. One reason for the lack of feedback information is the predominance of particularly strict anthropocentric methods and beliefs in some approaches to economics. In these approaches, the entire world is interpreted solely in terms of monetary values. Essential natural resources and processes provided 'free' by ecosystems are acknowledged only in the context of speculation about how much money must be spent to artificially engineer replacements. Failure to recognize the prior existence of free ecosystem services prevents prices from reflecting increasing scarcity when the ability to provide these services is destroyed and *not* replaced, or when actual spending must increase to replace them artificially.

Disregard for Scale and Complexity. The information deficiency also exists because strict anthropocentric methods and beliefs in some approaches to economics do not consider questions of absolute scale or the complex dynamics of ecosystems. Hence, they provide no criteria by which to judge cumulative effects; such methods have nothing to say about whether the alteration

Excerpts from a workshop discussion on composite ecosystem indicators:

Ecologist:	*"In my field you would be laughed out of court if you tried to describe a non-linear system with less than three variables. One measure, by itself, won't describe a non-linear system."*
Economist:	*"I do not think it is possible to have only one measure. A very small subset of variables may serve – say three. Most people can weigh only three variables at a time."*
Indicators Specialist:	*"You begin to see a 'layering' of needs for indicators. The indicators needed will be derived from different disciplines."*

of one marsh or sixteen marshes may be acceptable, permissible, or worrisome.

Incompatible Data-Gathering Norms. Another obstacle to generating feedback is that administrative and industrial classification boundaries are not related to the functional boundaries of ecosystems. Indicators of change that span sections of several jurisdictions are often needed. Instead, local or regional decision-makers often make decisions based only on information about their own geographical section of an ecosystem. Consider, for example, a municipal decision about a single resting or feeding site used by animals that seasonally migrate thousands of kilometres. The cumulative effect of a series of local changes can affect the performance of major ecological functions; hence, the influence on a watershed of a logging operation, a tourist development, and acid rain should all be weighed together.

Improved compatibility of data across jurisdictions, disciplines, and objectives is a fundamental step toward solving this problem. But participants agreed that this will require much greater collaboration in setting micro-level data collection standards. Currently, huge sums are paid for data collection to address numerous micro-level questions, with little consideration of future or alternative uses for these data. This causes duplication, and prevents the linking of different databases for applied or even theoretical work on the interconnections among the various factors at work in an ecosystem.

Communication among Economists, Ecologists, and Policy-Makers

To communicate effectively, economists, ecologists, and policy-makers must learn something of each others' language. Some participants thought that economists and ecologists can most directly communicate on *energy/materials analysis* (for example, building on pioneering work by Nicholas Georgescu-Roegen). Several participants were interested in 'full-cost pricing' of economic activity, which considers changes to ecosystem health and available resources when interpreting prices. As yet, little practical work has been done to quantify price adjustments. But their application in the real world of economic decision-making must acknowledge that these revisions can only be as precise as our knowledge of ecology.

To this end, several participants felt that ecologists should express their knowledge about ecosystems in ways that economists and policy-makers can understand and use in local, regional, and global applications. On the other hand, if economists and policy-makers expect to make use of this information, they must understand the essence of ecosystem dynamics, and adapt their analytical and decision methods according to the requirements of maintaining ecosystem health or integrity.[10]

Some fundamental differences need to be resolved. Ecologists often insist that orthodox economists need to change their attitude that economics overrides ecology. Orthodox economists believe that ecologists threaten to impose a freeze on economic activity. (Each group claims that the accusations made against it are based on misunderstanding.) In practice, policy-makers and the public receive many conflicting signals.

Ecosystem scientists, economists, and environmental policy-makers all need to improve communication with the public. Participants felt that professionals in each discipline should learn to respect and comprehend non-scientific environmental knowledge, and appreciate the co-existence of alternative perceptions. This is crucial because public perception and scientific knowledge are often disconnected, and this divergence influences which indicators and presentation formats motivate the decisions people make daily.

[10]Some participants speculated about economic interpretations or analogies of species diversity, trophic chains, efficiency, and lengths of material cycles, but others warned that analogies from ecology to economics are likely to be misleading.

Decision-Making[11]

Introduction

Much of the discussion in this round focused on how decision processes, and the analytical techniques they use, can influence the pursuit of indicators. Ruitenbeek's paper surveyed alternative political and economic settings for collective decision-making, types of indicators, approaches to decision-making under risk and uncertainty, and economic analysis techniques. Workshop participants examined factors affecting the decision-making setting and the implications for relative information needs. The matter was further discussed in terms of the needs of particular users. Participants also considered the relationship between monetary values and environmental assets, a subject dealt with in the discussion on capital, but this time in the context of decision-making. This led to a discussion on how to accommodate ecosystem requirements for which there are no realistic prices.

Importance of the Decision-Making Environment to Indicators

In his paper, Ruitenbeek reasoned that the decision-making environment is an important determinant of the type and quantity of information required. Several participants agreed that decision structures based on free-market principles tend to be less information-intensive than those that are centrally planned. However, this is partly because the free-market economy neglects certain relevant global indicators. But some participants emphasized the relative information needs of healthy (developed) and debilitated (developing or less developed) economic systems, to arrive at ecologically sound decisions. One participant identified a third approach to the question regarding the degree to which decision processes tend either toward 'economic rationality' or toward other cultural, sociopolitical, and emotional motivations. It was also emphasized that the ever-changing array of policy interests and powers in a society will affect, and be affected by, the availability and focus of information. Finally, differences for indicator requirements between decisions under risk and decisions under uncertainty were discussed. Discussions on these five factors are summarized below.

[11]The delineation study for this round was "The Role of Indicators in the Decision Process," H. Jack Ruitenbeek. In *Economic, Ecological, and Decision Theories: Indicators of Ecologically Sustainable Development.* Ottawa: CEAC. 1991.

Free-Market versus Planned-Market Economies

Participants debated the proposition that *free-market* methods of allocating resources would generally require different, and probably fewer, indicators than *planned* economies, to produce efficient outcomes.[12] Some argued that both types of economies generate the same spectrum of environmental problems. Hence, corrective decision-making in either case demands the same 'quantity' of information. Whether prices are determined through free-market trade or in state planning offices, ecological indicator support is needed for the price system to play a more effective role in guiding sustainable development. Even in an ideal free-market system, a central authority would still need ESD indicators to assess and assign relative price adjustments among constituents for market imperfections or externalities that destroy their common ecological foundations.

Healthy versus Debilitated Economies

Someone suggested that decision-makers in any *healthy* economy will probably need less environmental and economic information to decide on corrective action than those in a *debilitated* economy. If prices do not reflect the environmental opportunity costs of decisions, it is probably easier for a robust economy to accommodate the structural realignments that 'full-cost pricing' would induce. The policy tools of a feeble economy are less operable, even if its population suffers the consequences of adjustment gaps and inaccuracies more directly. More effort, and consequently more information, may be needed to devise an adequate response.

[12]It was noted that oligopolistic- and mixed-market economies partially constrain individual choices and detach outcomes from individual market decision processes. If command and control types of policy are used for sustainable development purposes, one participant suggested that there will be less and not more individual decision-making and a move away from the genuine use of 'free-market forces'. This discussion represented not so much a perspective against command and control, as a rejection of certain types of restrictions being indirectly placed on individual choices. Furthermore, it is not always clear whether individual or centralized decisions determine events in oligopolistic and mixed economies. For example, said one participant, allocating huge sums of money for freeways rather than mass transit service may be followed by an appeal for more freeway funding, based on the 'market forces' represented by commuters forced to use superior freeways rather than unmaintained transit services.

Rational versus Subjective Decision-Making

A fundamental distinction was made between environmental information needs to support *rational* compared with *subjective* (more precisely, 'affective') decision processes. A major difficulty with emotional decision-making is that all information theoretically becomes relevant since general or consistent criteria for categorization and prioritization may not exist. Different approaches to analysis and judgement can have markedly dissimilar information requirements. Much economic analysis is formulated on the assumption that people are rational decision-makers. Many participants considered this contrary to evidence. At least, different kinds of rationality exist. It is worth clarifying here, however, that the working assumption of homogeneous rational decision-making in economic methodology is intended to:

- simplify presentation (for one thing, no longer is *all* information relevant);
- test hypotheses; and
- specify the conditions under which a theory would be valid.[13]

Single-Objective versus Multiple-Objective Decision-Making

A participant observed that we must contemplate *who* is using information to make decisions and *why*, before we can determine what or how much knowledge will be useful. Who the decision-makers are is critical. The process usually involves a complex encounter between numerous senior decision-makers and the momentum of myriad local decision-makers who make up the population. Rarely does a single objective drive a public policy decision. Despite the clear directions that a sustainable development policy framework may appear to take, it was observed that there can be a great difference between how the decision processes work and the way many of us think they work. When many separate objectives exist, societies are at best only 'muddling' toward sustainability. Someone suggested that multiple-player 'payoff matrices' could be devised for different policy objectives and potential scenarios. Yet each group's objectives, as well as policy-makers' own criteria, are ever-changing because information is not a neutral input to the process.

Quantifiable Risk versus Conditions of Uncertainty

A participant explained that a gambler can assess *risk* when the number of sides and the markings of the dice are known; but the gambler plays under *uncertainty* if the shape of the dice is not known. While the risk of an accident from human activity can be statistically estimated,[14] uncertainty about repercussions in the ecosystem is not quantifiable. It was proposed, nevertheless, that indicators supporting decision-making under uncertainty are relevant.

Technical Rigour or the Rough Idea?: Particular Needs for ESD Indicators

Each group – communities, decision-makers in government and business, natural scientists, economists, administrators, law enforcement personnel, project field managers, and others – needs different types of indicators of the integrity of its economy and ecosystem. Political and public decision-makers make broad policy decisions, but administrators, entrepreneurs, and field managers deal with more specific and directed decisions. The corresponding substance and level of detail on what each needs to know about ecosystems and economics differ. For example, the public says we need cleaner water, politicians say we need a municipal strategy for pollution abatement, and administrators say we need to define standards, monitoring techniques, and benefit-cost mechanisms. The detailed technical indicators should help administrators and field personnel, while maintaining a clear link to the public demand for indicators of cleaner water. Diverse indicator types *can* complement each other in a logical hierarchy.

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[13] In *Essays in Positive Economics*, Nobel Laureate Milton Friedman states: "a theory cannot be tested by comparing its 'assumptions' directly with 'reality'. . . Complete 'realism' is clearly unattainable, and the question whether a theory is realistic 'enough' can be settled only by seeing whether it yields predictions that are good enough for the purposes at hand or are better than predictions of alternative theories. Yet the belief that a theory can be tested by the realism of its assumptions independently of the accuracy of its predictions is widespread and the source of much of the perennial criticism of economic theory as unrealistic. Such criticism is largely irrelevant, and, in consequence, most attempts to reform economic theory it has stimulated have been unsuccessful." (Friedman, 1953: 23; 41)

[14] In a major effort to address the concerns of the community, participants discussed how industry has progressed from straight *risk assessment*, to *risk management*, to *risk communication*. Risk analysis has evolved into a broader process in which quantitative risk assessment indicators form only one input into the decision-making process. The new process includes educating the public about the concept of risk, and about its role in decision methods. One member noted that this broad approach has been implemented successfully in hazardous-waste management in Alberta, but has faced implementation problems elsewhere.

Participants generally agreed that the indicators used by the public have at least as much effect on real-world decisions as the more technical, analytical indicators designed for specialists, administrators, and decision-makers. For example, someone mentioned that in Southam News' recent publication on indicators, public interest in the environment did not appear to respond as much tc financial concerns as to references such as how many miles of beach were closed to shell fishing or swimming.

Using the closure of a beach as an indicator says nothing about the causes of and possible solutions to the situation. Nonetheless, the public may believe this is evidence that *some* action is necessary, and then look to someone else to determine what that action is. One alternative is that the public will use such indicators to assign blame. General messages like this can be transmitted effectively through elected representatives, and through buying patterns, to affect major decision processes. As a result, policy and business decision-makers have to take unrigorous or even 'flimsy' indicators seriously when they reach the media.

Present versus Future Information Needs

Since information takes a long time to be gathered and incorporated into decision-making, should we put more effort into designing ESD indicators for present needs, or try to anticipate what types of indicators will be needed 25 or 30 years from now? Our analysis of many current problems depends on the knowledge assembled over the last several decades, even though indicators considered necessary in the 1960s were very different compared with those of the present. Perhaps an appropriate orientation for current indicators will involve a 30-year anticipation of indicator needs.

Clearly, we must fashion indicators that respond to questions peculiar to our present situation. Yet our children's generation will have to define novel indicators suited to its own needs, using information on trends that only we can provide. No consensus was reached on how to rank intergenerational needs for information. But it was generally agreed that circumstances change in unforeseen ways so, in principle, it is important to contemplate the adaptability of the information base we develop.

Using Imputation for Deciding among Alternatives

The *opportunity cost* analysis of mutually-exclusive alternatives compares the respective 'values' of alternative resources or activities. To more explicitly define the trade-offs among non-marketed environmental stocks and flows, hypothetical monetary values are often attributed as if the existence of these assets is, or could be, exchanged for cash in the market.

Workshop participants debated whether decision-makers would find imputed values useful when faced with choosing between money-generating activities that jeopardize ecosystem integrity, and ecological conservation that would constrain money-generating activities. Several members suggested that simulated monetary values would simplify including a wider set of considerations into the existing price-based decision framework. They felt that economic analysis must include the explicit valuation of non-market, non-priced goods and services, if these are to be part of economic decision-making. Everything that can be so valued should be included to incorporate as many factors as possible into the common denominator of money, to establish relative prices with which market-based decision systems can operate. For example, if Ontario imposes environmental limits on the power it produces, and then imports electric power produced by coal-fired plants that cause acid rain, the imputed value associated with healthy lakes would be an important factor in the real import price.

Some participants disagreed about whether imputation of values would be helpful. When prices are imputed, we should remember that these valuations, as with actual market prices, will change according to consumers' personal perceptions of aesthetics, ethics, and well-being. This presents some practical difficulties if users expect imputed values to represent 'realistic' prices for environmental assets, since different methods for ascertaining 'realistic' prices produce disparate results and are context-specific. Thus, it is difficult to assign imputed values that remain relevant over time. Some participants questioned whether the approach works at all for the type of medium- or long-term analysis that dominates ecological economics and sustainable development policy discussion. Thirty years ago, society would have given environmental assets a much lower imputed value than we would, with hindsight, under identical circumstances. One participant believed that imputation is futile and

ineffective because the public does not respond to such indicators.

Most participants agreed that even if opportunity cost valuation techniques for imputation are used, biophysical constraints on the operation of the price system are still needed to make decisions. Decision-makers need both economic and biophysical types of indicators, and they must reach beyond questions of monetarily assessed efficiency.

Policy Responses to the Operational Constraints of Ecosystems

To conserve indispensable parts of ecosystems for which there are no realistic prices, several participants agreed that a population should *collectively choose* biophysical boundaries that regulate *individual choice* in the market. This could involve specifying relative priorities (mining versus recreational use in particular regions) or absolute limits (a percentage of the land and water area within a jurisdiction that is left as wilderness).

It was felt that only biophysical constraints superimposed on market trade can suffice when the consequences of making mistakes are great and the uncertainties high. Constraints can close otherwise endless debates about the relative costs and benefits of particular types or locations of activities. Economic models can also integrate these constraints to improve their predictive results. However, estimating and applying relevant operational constraints is not easy.

The key question on indicators, noted one participant, is how best to superimpose ecosystem constraints on the market-based decision and value structure. Indicators are needed that describe the relative or combined importance of various ecosystem qualities and express the terms in which biophysical constraints will be promulgated and enforced. The point was also raised that, to be useful to decision-makers, indicators of activities must link to indicators of consequences. Knowledge that officially permitted levels of nitrous oxide (N_2O) were exceeded so many times per year is not as meaningful as when there is a clear correlation to the number of asthma attacks or increased building damage rates.

One participant cautioned that the simplifying assumptions needed to apply ecosystem constraints to economic behaviour can neglect crucial elements that deserve attention. For example, as human activities alter the complex natural processes of ecosystems, measurement and monitoring agencies tend to evaluate their effects according to initial, rather than medium- or long-term results. If everything appears to go well initially, monitoring personnel are apt to assume these activities are within the ecosystem's 'carrying capacity'. But ecosystem limits evolve discontinuously, and favourable incremental change in an indicator does not necessarily imply that we are heading in a desirable direction. Furthermore, major human interventions in ecosystems tend to induce the evolution of more rigid system boundaries, whereupon changes in state are more likely to occur abruptly and with surprise. Even a cursory understanding of the functional dynamics of ecosystems makes it clear that biophysical constraints on economic policy cannot be fixed 'once and for all'. They must be reviewed from time to time, based on new circumstances and knowledge. The policy framework they assist should be fundamentally adaptive.

3 Applications of ESD Indicators in Investment, Taxation, and National Accounting[15]

Project Appraisal for Financing Conservation Investments

Introduction

During this round of the workshop, participants considered the appraisal of financial expenditures for ecological conservation. The focus was not on whether money should be spent to maintain ecosystem integrity. Rather, having decided to spend such money: Where should it go?, and How is the best 'value-for-money' project determined? Before the workshop, participants reviewed discussion notes on a *Framework for Program Design and Allocation Criteria* for a proposed Global Environment Facility (GEF), which had been circulated two months earlier by the World Bank at a meeting of potential donors to such a multilateral fund.[16]

The GEF document was chosen as a vehicle for discussion of investment appraisal because it directly addresses the question of value for money through conservation investment in four proposed areas: chlorofluorocarbons (CFCs), greenhouse gases, biodiversity, and marine pollution. Several important issues related to appraisal concepts and methods are reported in the following sections. As the origins of the GEF are not widely known, a brief account follows.

The 1987 report of the Brundtland Commission (World Commission on Environment and Development) urged that "serious consideration be given to the development of a special international banking program or facility" to increase "investments in conservation projects and national strategies that enhance the resource base for development." Following that recommendation, in 1988 the United Nations Development Program (UNDP) commissioned the World Resources Institute (WRI), with financial support from the Canadian International Development Agency (CIDA) and others, to identify innovative means of investing in the maintenance and restoration of the natural resources of the developing world. In its report of September 1989, WRI expanded on the concept of a central International Environmental Facility (IEF) or several regional IEFs that could serve as intermediaries among developing country governments, multilateral agencies, and NGOs to help identify promising conservation programs and mobilize technical and financial support.

When the WRI report was released, the government of Germany led discussion at the September 1989 Development Committee of the World Bank toward a review of alternative funding mechanisms for global environmental conservation. At the December 1989 annual meeting of the World Bank, the finance minister of France, Mr. Beregovoy, suggested the World Bank should begin to actively explore the establishment of a $1 billion pilot environmental facility to fund projects in developing countries that would help meet global environmental objectives. He offered FFr900 million over three years of French government support to this facility. This prompted a more focused series of bilateral and multilateral discussions, beginning in January 1990.

Dr. Mostafa Tolba, Director of the United Nations Environment Program (UNEP), suggested a tripartite arrangement involving UNEP, UNDP, and the World Bank. UNEP could play a key role in strategic planning and provide scientific and technological guidance on environmental information, research, and analysis. UNEP has been a key forum for negotiating global environmental policies through multilateral agreements on issues related to the global commons. UNDP, however, could play the principal role in conducting preinvestment studies and offering technical assistance for institution-building and training for management and coordination. UNDP has extensive field presence locally in developing countries. Finally, the World Bank could manage daily administrative work and develop proposals for its work program with UNEP and UNDP. The World Bank would bring to the arrangement its background in project formulation, aid coordination, policy advice, and program implementation.

[15]The delineation study for this round was "Proposed Allocation Criteria". In *Funding for the Global Environment*, Discussion Note 1. Washington D.C.: the World Bank. May 1990. Salah El Serafy (Economic Advisory Staff, the World Bank) had the role of reference participant.

[16]CEAC would like to thank the World Bank for permission to distribute the GEF discussion notes among workshop participants.

A discussion paper prepared by the World Bank in February 1990 (*Funding for the Global Environment*) suggested a three-year pilot GEF, premised on general administration by the World Bank with programs implemented jointly by the World Bank, UNDP, and UNEP. At the Development Committee's Paris meeting in March 1990, about 20 donor countries appeared likely to put forward a total voluntary contribution of $1 billion to $1.5 billion for the three-year pilot phase. Various flexible financing arrangements include both core grants to the fund and untied bilateral cofinancing schemes (whereby grants or low-interest loans to the GEF are matched with support to other aid agencies) to enlarge the program's scale.

At the time of CEAC's workshop in July 1990, the GEF was still in the proposal stage. Since then it has quickly taken shape. Multilateral discussions have resolved that in its pilot phase, a GEF should have two distinct trust funds. This allows other funds to be created as new global environmental agreements are eventually reached. The Ozone Projects Trust Fund has already been established by contracting parties to the Montreal Protocol (adopted 1987). The World Bank will be the executing agency under the GEF umbrella. A separate Global Environmental Trust Fund will address greenhouse gases, marine pollution, and biodiversity. Donor countries officially announced the form and level of their participation in the GEF pilot phase in May 1991. The first preparatory operational meeting is planned for December 1991.

Criteria for Financial Assistance

Economists refer to goods and services that may be enjoyed by all members of society as 'public goods'. Investment in public goods would thus include conservation activities that help maintain ecological integrity, such as projects that preserve species, protect atmospheric ozone, maintain hospitable climates, and reduce pollution of the oceans. When a particular country acting alone does not receive a sufficient share in the global benefits to set the project in motion, a case can be made for national and multilateral institutions to help with financing.

The discussion document *Funding for the Global Environment* distinguished the circumstances under which conservation investments (in countries receiving assistance from the World Bank) should be considered for multilateral financial assistance:

Type 1: The benefits to be realized by the implementing entity are sufficient for it to justify meeting the full cost of the conservation investment. Type 1 projects would usually *not* be eligible for financial assistance.

Type 2: The conservation investment would not be justifiable for the entity if it would have to bear the full cost of implementation. But if part of the cost can be offset by concessional assistance, then the overall project can be made attractive to the implementing entity, and substantial environmental benefits can be realized. Type 2 projects would be eligible for financial assistance if they meet the required cost-effectiveness criteria.

Type 3: The conservation investment is justifiable to the implementing entity, but design modifications would yield substantially greater environmental benefits. Type 3 projects would be eligible for concessional assistance if they meet the required cost-effectiveness criteria.

Considerable discussion at the workshop was related to the condition: "if they meet the required cost-effectiveness criteria." The evaluation methodology applied becomes critically important, although, as one participant admitted, there is little experience upon which to draw for allocating scarce funds to ecological integrity objectives. Some pilot projects in type 2 and 3 situations would need to be conducted to determine what constitutes good value per dollar of assistance. Hence, what is the maximum justifiable financial assistance per unit (or equivalent unit) of reduction in harmful emissions like CO_2, CFCs, or oil spills, after which it would be more cost-effective to leave events to market forces?

The cost-effectiveness criterion is helpful in allocating public funds among potential options. For CO_2 emissions, consideration might include subsidizing alternative types of energy-efficient equipment, or forest conservation programs, compared with the cost of letting market forces respond on their own to the threat of expected climatic changes. Another example offered was that perhaps a relevant option for reducing certain types of pollution would be for a public agency to buy up the patent rights to safer chemicals or processes and disseminate production licences free, rather than letting the market set the prices

on access to these alternative technologies. Generally, if a lot of public financial assistance can be expected to buy only a small reduction in pollution compared with market forces alone, then direct public expenditures on such projects would not be cost-effective. However, other types of intervention to alter market characteristics might still be desirable.

But several participants emphasized that there is no 'exchange price' on ecological integrity. The profound importance of conserving biological diversity, the ozone layer, or hospitable climates cannot be measured in monetary terms. Some felt that species extinction is an ethical issue, so each species' intrinsic value is beyond dispute and the cost-effectiveness concept cannot be applied. To support this view, the point was raised that many types of projects already supported by public and multilateral agencies are financed according to a *cost-efficiency* principle – decision-makers set a target for ethical, health, cultural, or other reasons and pay the minimum cost to get the job done. One participant noted that appraisals of this sort sometimes apply a point system – in this case, it could be based on ecological benefits – without the need to calculate a monetary rate of return.

Even with an ecological point system, however, some were concerned that decisions about what aspects or parts of ecosystems should be given priority protection remain arbitrary. Since human societies are already on an ecologically destructive course, decision-makers must choose among the various 'claimants' for differing kinds of physical or ecological values. For example, for biological diversity, it may be necessary to choose among varieties of bananas or potatoes, potential medicinal plants or insects.

Another idea discussed was estimating the full eventual expense of medium-term clean-up of an oil spill, such as that from the Exxon Valdez, and having Exxon contribute that amount of money to an environmental investment fund. The fund would aim to maximize the ecological benefits per dollar of conservation investment. If money would be most effectively spent in fully cleaning up the Valdez spill, that is where it should go. However, after initial damage-control efforts, if the same money could be applied with greater ecological advantage elsewhere, it should be directed to such activities.[17] If the integrity of one ecosystem is compromised, but another is enhanced to a relatively greater degree, then strictly preserving each ecosystem individually may not be the most effective overall policy.

Others argued that such trade-offs should not be necessary. They noted that many of the pressures on ecosystems result from perverse economic incentives. Correcting these deficiencies is more efficient than trying to counteract a persistently destructive economic trajectory with isolated conservation projects. Progress can be made in stopping or reversing degradation in all ecosystems through changes to the general orientation of macroeconomic policy. An ecologically sound overall policy and institutional framework would reduce the cost of meeting vital physical and ecological criteria. It would also eliminate much of the need for giving public assistance to conservation investments, which now compete for scarce funding. Participants agreed that the eligibility of conservation projects for financial assistance would depend upon the reference policy framework. For example, reforming the tax system to incorporate ecological considerations might change some projects from type 2 or 3 projects to type 1.

One problem mentioned with some forms of conservation investment is that subsidies might appear as payments to 'stop doing bad things'. It is as if the recipient were saying, "Fund my environment project or I will destroy this valuable ecosystem." The appraisal criteria may also create an incentive for proponents to make potentially eligible projects look particularly bad with regard to their own interests, just to attract extra funds. Although some applicants for assistance might underestimate their own benefits, any financial assistance program must evaluate similar claims. Playing down the local benefits may even encourage financial support to shift to more self-sustaining projects.

Scope and Methods for Project Appraisal

The project-specific decision context poses unusual demands for information on conservation investments. This is because it will often be difficult over the short term to establish results at relevant scales, such as marginal changes in biophysical features like atmospheric concentrations of CO_2 and CFCs, or the incidence and location of oil tanker spills. For several types of conservation investment, a three-year trial period is unlikely to provide enough time for chosen indicators to reveal any significant outcome. Allocation decisions must rely partly on imprecise

[17]For further discussion of this issue, refer to pages 30-31.

> *This approach to calculating the amount of GEF financing for a project provides a straightforward way to apply the cost-effectiveness principle to selecting among projects that address the same objective: select projects with the highest ratio of benefits (measured in physical terms) per GEF dollar. For greenhouse gases, this would mean calculating the reduction (in tons) of CO_2 equivalent per GEF dollar; other gases such as methane would be converted into CO_2 equivalents using standard coefficients based on the greenhouse impact of the gases. Similarly, for the* ***ozone layer*** *and* ***marine oil pollution****, one would calculate the quantity of CFC emissions or oil pollution saved per GEF dollar. This approach could not be applied as straightforwardly to* ***biodiversity****, because there is no applicable standard measure. The number of hectares preserved per GEF dollar could be used as a first approximation of cost-effectiveness, but some hectares are more critical to biodiversity than others (various studies already pinpoint major areas of biodiversity). Therefore, some widely accepted method would need to be developed to weigh the biodiversity value of particular sites.*
>
> *Funding for the Global Environment.*
> Discussion Note 1: "Framework for
> Program Design and Allocation Criteria."
> Washington D.C.: the World Bank. May 1990.
> *(Excerpt from page 13, paragraph 23; emphasis added.)*

ecosystem and socioeconomic scenarios sketched out over 20 to 50 years.

> ***"Everything I have heard says that there is now inappropriate theory for deciding on allocations, but the pieces for an appropriate theory are there."***

In workshop deliberations, it was emphasized that the scope and methods of ecological investment appraisal are unlike those for conventional economic assessment. For example, a participant explained that if one is considering a reforestation project over 50 years, it is not just the 'trees as wood' that is considered. We must also assess the forest's contributions to water cycling, wildlife habitat, air cooling, soil regeneration, erosion prevention, enhancement of fish habitat, carbon fixation, etc. These benefits are not part of conventional economic appraisal because they would not be marketable by an investor looking only to sell something. Without ways to share the cost of planting forests for common ecological benefits, such investment does not occur.

When assessing returns on conservation investments, few consider it plausible to assign financial values to ecological benefits as if they could be exchanged, and to decide who the beneficiaries are for each of the various ecological functions. However, it was mentioned that indicators can be designed that measure *effort* as well as the *cost of effort*, such as so many tons per dollar of carbon-equivalent reduction for projects. The discussion document suggested that priorities should be set for the ratio of expected physical benefits per invested dollar. No attempt is made to directly attribute monetary values to global ecological benefits. The document explains that "cut-off ratios need to be established to ensure that an excessive price is not paid to achieve a given global physical benefit. For example, the unit cost of an oil-spill cleanup could provide an upper limit for preventing the dumping of a ton of hydrocarbons. With experience and research, these ratios would be increasingly refined, enabling them to be used to balance applications for GEF financing against the available resources." (*Funding for the Global Environment*, p. 14.)

The Role of Judgement

Discussions about cost-effectiveness in conservation investment led to questions on how a financial institution should allocate money among different classes of potential projects (in this case, reducing emissions of CO_2 and CFCs and ocean

oil pollution, and conserving biodiversity) and how it should evaluate the relative performance of these funding allocations. To gain the confidence of conservation investors, it will be necessary to convince them that rational principles will be used. But participants expressed some apprehension about benefit-cost analysis 'gone wild'. They emphasized that it is impossible to compare these sorts of projects, given the complexity and diversity of ecosystems and our limited understanding. Informed judgement will be crucial. The discussion document states, "Priority among the four global environmental concerns would need to be determined more subjectively, because the benefits of biodiversity and, say, the ozone layer, cannot be compared directly with each other." It explains, nevertheless, that "the need for broad judgement about priorities between the different global environmental issues is analogous to the way that intersectoral allocations are made now by the World Bank and other agencies." (*Funding for the Global Environment*, p. 14.)

The issue was therefore raised: *whose* judgement is being brought to bear and *where*, for designing and operating the fund. Furthermore, who within recipient countries will determine the hierarchy of projects? Someone commented that funding in many other situations has tended to stray to activities that are easiest to monitor, rather than those selected according to rigorous criteria.

It was explained that the four subject areas for the pilot phase of the GEF were selected and rated according to donor wishes. That is, the four areas were given 'from the outside'. Some participants wondered if the World Bank and United Nations would have chosen these particular four applications on their own. They felt the investment objective may be leaning more toward satisficing than optimizing.

Considering Biological Diversity

Of the four investment objectives discussed, biodiversity was the most difficult in terms of implementing firm decision criteria. One participant mentioned that biological diversity can be viewed as a process, a goal, or an indicator. Yet there is no consensus on how to influence the process, reach the goal, or use the indicator. All agreed that the scientific community must play a key role in setting priorities here, but economists also have a pivotal role in implementing them.

Several participants stressed the need for precision in using the phrase 'biological diversity'. *Species diversity* is the variety and representation of living organisms on earth. *Genetic diversity* is the variability within a species. *Ecosystem diversity* is the variety of ecological complexes in which species participate. According to these definitions, it is still necessary to determine whether conservation investments would aim to achieve *optimum* diversity in selected locations, or conserve *minimum* diversity more generally. More detailed discussions on these types of biological diversity are summarized below.

Species Diversity

Species diversity is the variety and representation of living organisms on earth, measuring both the total number of species (species richness) and equity among community members. Two operational guidelines were proposed for policy and information on species diversity.

Key species. *A small number of key species appear to maintain the dynamic architecture of any ecosystem.* Little research has been done on the key species concept, but evidence suggests that only a few critical players deliver the temporal and spatial stability of each ecosystem. All other species are 'along for the ride'. The role of biological diversity in an ecosystem is critical, but it is not a simple matter of how many species there are. The loss of one species in a northern temperate forest is generally much more critical than the loss of one species in a tropical rainforest. The spruce budworm is certainly one of the key species in the renewal of northern boreal forests. In this case, the existence of the budworm has global implications.

Indicator species. *There are indicator species whose scale reflects how the ecosystem works.* While some indicator species may also be key species, many do virtually nothing to sustain the overall dynamics of their ecosystem. Instead their condition can render useful monitoring data across spatial, temporal, and other boundaries. Indicator species are so designated because:

- they are easy to get information about;
- they illustrate important effects, such as biomagnification of pollutants; or
- they are 'charismatic' to humans (for example, information about the well-being of high public profile animals like hawks and eagles in the Great Lakes region, flamingos in the Everglades, and panda bears in China, carries 'political muscle').

Genetic Diversity

Genetic diversity is the variability within a species, measured by variation in genes. Ancient types of corn, potatoes, wheat, tomatoes, medicinal plants, or unique subspecies may each have genetic traits of potential significance. In pharmaceutical applications, these could be crucial in dealing with unknown diseases or they could be used to control pests that destroy monocultural hybrid varieties used in present-day agriculture. Preservation of the options provided by a large gene pool including unique genetic materials is crucial to the future adaptability of all species – ourselves included – to environmental change and the unpredictable evolution of parasites and diseases.

Ecosystem Diversity

Ecosystem diversity is the variety among ecological regimes in which species participate, measured by the variety of substrate and supporting media characteristics; spatial and temporal aspects of nutrient, sunlight, temperature, and water cycles; and the characteristics of species association. It was argued that species diversity cannot be sustained without maintaining the health of the ecosystems in which they exist, so the biological diversity question depends on our willingness to conserve these ecosystems.

Excerpt from *Funding for the Global Environment*:

"The number of hectares preserved per GEF dollar could be used as a first approximation of cost-effectiveness, but some hectares are more critical to biodiversity than others (various studies already pinpoint major areas of biodiversity). Therefore, some widely accepted method would need to be developed to weigh the biodiversity value of particular sites."

Question from workshop handout:

"How would one choose between a thousand hectares that are especially rich in terms of biodiversity, and a million hectares where only a few species are found? That is to say, is a Canadian conservation dollar better spent preserving tropical forest 'hotspots' via the GEF, instead of a wide expanse of arctic terrain?"

Comment by an ecologist at the workshop:

"The role of biodiversity in the functioning of the ecosystem is critical. There are a small number of key species that determine the architecture of an ecosystem, such as spruce budworm in the renewal of the forest. All other species are along for the ride. The loss of one species in a northern temperate forest is much more critical than the loss of one in a tropical rainforest. There has yet been no work done on the key species idea."

'Present Value' Calculations

Investment appraisal methods must express future monetary values in terms of their worth at the time a decision is being made. An important consideration in determining 'present value' is whether, or how, the passage of time should relate to the face value of money, and thus to the figuring of indicators in monetary terms. It is usually presumed in Canada that the average economic return on a financial investment is about 10 per cent per year – one dollar invested today would return about 10 cents of revenue a year from now, over and above the original dollar (adjusted for inflation). To simplify investment decision-making, an annual 'discount rate' of 10 per cent is usually applied to future monetary values. So, $1 next year is taken as $1 divided by (1 + .10) to equal about 91 cents in today's decision context, and $1.10 a year from now is taken as $1 today. This admittedly crude rule of thumb is useful in comparing investment alternatives, because it acknowledges that if a dollar invested today yields only 9 cents in a year, the investor would be getting a less-than-average return – next year's $1.09 would have a present value of about 99 cents. The investor who wants to maximize future benefits should put the dollar into something more lucrative.

But several participants felt that when natural resource depletion rates and changes to ecosystem integrity are included in the calculation of average investment returns, an appropriate discount rate for investment appraisal could be as low as 2 to 5 per cent, rather than the 10 per cent usually applied. This would change the temporal weighing of decisions to a longer-term investment horizon, which they felt would be more appropriate to sustainable development. This is important so that intergenerational equity is considered in economic policy and decisions, since discounting can make future benefits appear virtually worthless to current interests. Someone pointed out that a 10 per cent discount rate will depict monetary values just 10 years away at merely two-

fifths their face value today; this time-frame is not an intergenerational concern, but relevant to workshop participants' own medium-term planning.

Others maintained that reducing the discount rate would *not* be useful, since a lower discount rate can just as easily play a role in environmentally damaging decisions. Furthermore, some maintained that government decisions rarely involve consideration of discount rates or financial rates of return. They contend that decision-makers assess a wide variety of considerations according to their own priorities, decide what they can fund, and proceed with public investments. It was suggested that distributional equity cannot be assessed with absolute ecological or economic value measures; rather, other types of indicators that reflect the erosion or attainment of specific principles of equity would be more appropriate.

Participants generally agreed that the discount rate used for investment appraisal by government should not be continually varied. A more fundamental issue, however, was that the resource and environmental effects of investment activity, previously excluded from the calculation of the average rate of return and the discount rate, should be included in the equation. Methods that would reflect resource depletion and the rate of functional regeneration of natural systems disturbed by development, would make the discount rate more useful for investment appraisal within an ecologically sustainable decision context. Participants were very interested in further examining how such an idea could be incorporated into the way the world does business.

Resource and Environment Provisions in Taxation[18]

Introduction

In recent years, many have advocated aligning the tax system with the objectives of ecologically sustainable development (ESD). Proponents would like to put environment and resource provisions into taxes as a way of changing consumer and entrepreneurial behaviour, and creating a more equitable system, by internalizing to perpetrators the costs associated with preventing (or having others put up with) degradation. New environmental taxes have also been proposed as a way for governments to collect the revenues needed to finance environmental protection specifically, or public sector activities in general.

Debate in Canada has mostly focused on pollution taxes, in particular, so-called 'carbon taxes' related to CO_2 emissions. Although they may have intuitive appeal, pollution taxes have not been widely adopted. This delay is partly because such taxes must be based on defensible estimates of the external damage costs that polluters should bear. There are different methods for estimating pollution damages, apportioning blame, and affixing tax liability. Many would rather preserve the better known regulatory approaches instead of locking the government into new tax schemes that could be less effective. Furthermore, an individual tax (such as on CO_2 emissions) may have undesirable distributional effects among sectors, regions, and income groups. Thus the economic effects of a single emissions fee must be analyzed in relation to other instruments as well as in the context of the overall fiscal policy.

Consequently, alternative instruments were discussed at the workshop, in addition to taxes, which, in combination, could lend flexibility to the range of potential economic measures useful to promote ecologically sound development. These include tradable emission rights, tax reductions, deposit-refund systems, or accelerated depreciation allowances on cleaner processing equipment, buildings, and durable consumer goods.

[18]The discussion paper for this round was "Taxing Pollution: An idea whose time has come?" Wallace Oates. In *Resources*. Spring 1988. Nancy Olewiler (Department of Economics, Simon Fraser University) was the reference participant.

General Policy Context

Workshop participants shared the view that market-based incentives should be preferred over command and control measures to meet environmental objectives. But some also cautioned that market-based instruments are not always better than regulations and standards, because their gradual approach can be ineffective in relation to catastrophic ecological thresholds, major damage from small errors, and irreversible losses.

Developing an effective mix of regulations and market-based instruments will be a complicated process. Among the various options, environmental taxes could prove most appropriate for achieving certain objectives, or to complement regulations or other market-based instruments. For example, tying environmental taxes to legislated standards may be useful when direct systematic enforcement may be too costly. At the same time, introducing environmental taxes could require eliminating entrenched subsidies and incentives elsewhere in the system that work against environmentally sound economic decision-making.[19] The main point, however, was that a new and detailed sector-specific tax code cannot be glued on top of the existing policy structure with the expectation that everything else will stay the same. A learn-by-doing process over several years will involve many complementary opportunities and contradictory dilemmas that will demand action by policy-makers.

Targeting Environmental Taxes: Producers or Consumers?

The issue was raised whether environmental taxes would 'level the playing field' or introduce a complex and inefficient differentiation among commodities. Most participants agreed that environmental taxes could remedy significant market distortions by increasing the relative prices of products and actions that contribute the most to ecological degradation. This would encourage more environmentally efficient producer and consumer behaviour. But there was some discussion about whether such taxes should be applied to producers at various stages in the production process, to consumers at the point of final sale, or both.

[19]Nevertheless, in the policy sphere several people have suggested that the government should provide accelerated deductions for the capital costs associated with upgrading old operations (say factories) to meet new government emission standards. The OECD has proposed that these would be consistent with the principle of 'polluter pays', if temporary.

Producer Environmental Taxes

Producer environmental taxes would create *a direct incentive for producers to change* their production processes by assuming the costs of preventing damage from processes likely to cause ecological degradation. If such costs are systematically built into sales prices, an indirect (but not fully consistent) effect can be to shift consumer demand toward commodities that cause relatively less ecological disruption during their production. If no consumption environmental taxes exist, the tax applied to producers could also be designed to reflect expected disruption through the use and disposal of the product or the performance of services.

Consumer Environmental Taxes

Consumer environmental taxes must be tied to particular types of commodities to *directly influence consumer behaviour* by increasing relative final sales prices of products and actions that contribute the most to ecological degradation. The effect of changing demand would be to shift investment away from the production of commodities that involve more environmental disruption through their use or disposal. If no production environmental taxes exist, the taxes applied to consumers may also be designed to reflect ecological disruption that occurs during production of the commodity.

Issues Raised in Relation to Tax Harmonization

Each country's relative industrial competitiveness is a shared concern in any discussion of resource and environmental provisions in taxation. Would environmental taxes in Canada need to be harmonized with those of other nations? Workshop participants could not agree. Would harmonized environmental taxes prompt the harmonization of other policies as well? No consensus emerged here either. Is there a need to first harmonize environmental data so we know whether other things should be harmonized? The consensus answer was yes. Workshop discussions of these three questions are summarized below.

Competitiveness

The increasingly liberal movement of capital across borders makes the harmonization of taxes affecting business profits an important concern. Corporate tax inconsistency is a major issue with the Canada-U.S. Free Trade Agreement, in negotiations on European economic union, and in other free-trade zones. One participant commented that taxes on domestic sales do not need to be harmonized if not applied to exports. But new taxes on corporate income, capital, or emissions of pollutants would directly affect competitiveness and, therefore, prospects for new investment. When examining potential new environmental taxes, it is crucial to assess just what such a system would do to the international competitiveness of an economy.

Some workshop participants felt that harmonizing environmental tax policy could be possible among G7 countries. However, such taxes are unlikely to be harmonized globally because national economic and environmental circumstances and policies are too diverse. Some thought that Canada should introduce new environmental taxes at the same speed as, or not much faster than, other G7 countries, especially the United States. Others felt that a switch to strong environmental taxes in a way that does not increase cumulative transfers from entrepreneurs to government, relative to other countries, would not push investment to other countries.

Implications for Expenditures

Assuming some progress toward multilateral introduction and harmonization of environmental taxes, some participants questioned what the implications would be for government expenditure patterns, environmental tax exemptions and credits, as well as broader legal and regulatory aspects. Some believed that harmonized environmental tax policies would make it essential that other policies correspond as well. Others thought that evidence for or against such consequences is inconclusive. A third contingent felt there would be no pressure to harmonize expenditures. Current negotiations for European economic unification are being watched for their internal policy effects.

Information Practices

Some important indicator issues need to be resolved before the tax issues can be settled. It was suggested that since taxes may only be applied to events or objects that can be measured and quantified, internationally harmonizing environmental taxes depends on some prior agreement about ways of measuring and portraying

relative ecosystem health and stress. Combined ecological and economic factors specific to each country would be important for determining environmental tax rates, and would involve information beyond simple measures of pollutant emissions. Negotiating common concepts, definitions, sources, and methods for environmental information is a prerequisite to negotiating common environmental taxes.

Revenue Considerations

A participant commented that existing 'quasi-environmental' excise taxes on fuels are levied on the basis of revenue targets, rather than on any assessment of pollution reduction. But most agreed that environmental tax rates should be determined by environmental objectives, rather than revenue considerations. Still, the revenue side is important in relating environmental tax rates to other sources of government finance. One member noted that if a new environmental tax were offset by a corresponding decrease in revenues from other taxes, sectoral balances in the economy would change favourably. However, another contested that it would make no sense to have a revenue-neutral change in the tax system. Instead, it was proposed that overall tax revenues must increase soon to pay for the additional costs of environmental protection. A big concern was that the ideological and practical opposition to more taxes is running up against the greater revenue needs for such essentials as toxic waste clean-ups. There appears to be considerable public support for introducing special environmental taxes, but some cautioned that the public's willingness to pay, expressed in surveys, does not mean that consumers and businesses would be able to hand more money over to the government. Participants agreed that an important determining factor would be how environmental tax revenues are spent. However, they differed over whether the proceeds should go to the environment, social programs, the deficit, or reduction of other taxes.

Several participants proposed that the revenues from new environmental taxes should be specifically directed to programs for essential clean-up activities, enforcement of environmental laws, and research on ecosystems and more efficient technologies. They cited opinion surveys in Canada and in other countries indicating that the public would almost be enthusiastic about paying pollution taxes if the funds were spent on these programs. Tying the revenues of a new environmental tax to such programs would help make them politically acceptable, and would thus be an effective and efficient way of changing behaviour.[20] Other participants said they would rather see new environmental taxes expressed in neutral terms. Proceeds should go to reducing other income, excise, and capital taxes, or they should go to the general government treasury to reduce the deficit. There may be an immediate appeal to earmarking additional tax revenues, but this approach would create too many operational constraints in the fiscal system and would be economically inefficient.

This debate provoked a clear difference of opinion among economists knowledgeable in the tax field. Some argued that earmarked taxes are "contrary to economic theory;" others maintained, just as strongly, that no economic argument has ever been raised against it.

Indicators for Setting and Indexing Environmental Tax Rates

Participants contemplated in more detail what indicators policy-makers might find appropriate for setting and indexing environmental tax rates. The design objectives for an environmental tax would determine many characteristics of the actual mechanisms and the operational indicators required. Hence, should a tax be specifically set to achieve stated results in terms of actual or projected ecosystem effects, or just to reduce the levels of harmful emissions to target levels? Two major approaches were discussed on how environmental tax rates should be indexed. Each needs different information support.[21]

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[20]One person suggested that if *all* tax revenues were clearly targeted for specific expenditures, the whole government revenue and expenditure system would become more rational and the economy might move to a more sustainable path. It was observed that such a fiscal system would depend on a clear vision of public policy objectives, an extensive information base for comparing the implications of alternative policy and program choices, and a high level of public participation.

[21]The information infrastructure needed to support different approaches to the design of environmental taxes is a key determinant of whether or not they could ever be implemented. For example, during one workshop discussion it was suggested that auto emission taxes might vary according to the average fuel efficiency of the model of car being driven. Other participants thought differential rates of this sort would make an emission tax far too complex: "What are the information requirements with such complexity?" Some argued that one advantage of an instrument like taxation is that it tends to require less centralized information to operate than command and control techniques. Furthermore, a tax based on fuel efficiency may be less effective in targeting emissions than a tax that links to the use of a vehicle, such as distance driven, or a surcharge on downtown parking lots. A simple system proposed in Toronto would have all car owners pay a standard fee, while public transit would be free.

Indexing by Degradation Effects

One approach to indexing environmental tax rates links the rate to indicators of ecosystem degradation. In this case, the rates should be set high enough to pay for preventing and/or repairing damage to the regenerative capacity of ecosystems. Hence, pollution tax liability should be equal to *an agent's total emission, multiplied by the marginal unit social cost of actions to repair the degradation and prevent further damage*, or equal to *an estimate of the marginal unit social cost of the degradation itself.*

Indexing by Price Effects

Another approach to indexing environmental tax rates is to link the rate to price effects – setting it just high enough to motivate the necessary degree of behavioural change to reach stated targets within ecosystem tolerance thresholds.[22] In this case, pollution tax liability should be assessed according to *an agent's total emission, multiplied by a value derived through analysis of relative marginal substitution prices among inputs.*

The two indexing options were not directly compared during the workshop. However, if the purpose of the targets in the price effects approach is to prevent and repair damage to the regenerative capacity of ecosystems, as considered in the degradation effects approach, then these two options should have the same result. The only practical difference would be *which* set of indicators proves more functional in the particular policy setting.

Spatial Considerations

Participants remarked on practical and strategic reasons why environmental taxes must somehow be tailored to the geographic scales and locations of sources and consequences of ecological degradation. Most felt that the more *global* the target of an environmental tax, the less likely it is that tax instruments can work; whereas, the more *local* the cause or effect, the easier it would be to apply tax instruments. Local taxes and user charges tend to be more politically acceptable than broad-based tax policies because people can see where the money is going and who bears the tax. However, a global or national environmental goal met through an assortment of disjointed local tax initiatives could prove cumbersome because the measures may be insignificant in terms of the environmental objectives. When environmental problems that need action do not coincide with a jurisdiction within which the relevant taxes are legislated and paid, it could also be difficult to make a system appear fair. Since environmental and jurisdictional concerns correspond to different spatial areas, some participants concluded that greater convergence between jurisdictional and environmental areas is needed. Others felt that criss-crossing jurisdictional and ecological borders need not cause problems. For example, it was reported that the tax base for water use in France varies depending on the quality of water, because rates are established according to watersheds spanning different municipal or departmental jurisdictions.

Other Market Mechanisms

Environmental taxes could be combined or substituted with some combination of other mechanisms that make use of competitive market energies. Two schemes were briefly discussed during the workshop: emission permit systems and remedial projects.

Tradable Emission Permits for Pollution within Ecosystem Carrying Capacity

An emission permit system would annually auction off entitlement to national, regional, or watershed pollution quotas established according to the environment's ability to benignly assimilate each particular type of emission. The total volume and/or rate of flow of pollution allowed under each year's quota would change with the assimilative capacity of relevant ecosystems.

The auction system would function only where there is a competitive market with lots of players. Thus, participants suggested that emissions causing widespread problems, like CO_2, SO_2, and CFCs, are fitting candidates for emission permit systems. But other types of pollution may be localized and dissipate harmlessly into the larger environment. In these cases, a market of the appropriate scale may have too few players. One person noted that if permits could be divided into

[22]Participants contemplated: What level of CO_2 emission tax would be needed to reduce global output significantly? It was suggested that a 4 cent per litre tax on gasoline may raise considerable revenues. However, to effectively cut demand, a 50 cent per litre tax may be necessary. But if a gasoline tax must be so huge to have any real effect, some questioned whether taxes should realistically be expected to achieve significant environmental gains.

small biophysical units, smaller polluting businesses could buy just the amount suited to their particular activities and more players could be accommodated. However, the smaller the units, the more difficult the monitoring burden becomes.

Many workshop participants agreed that a key problem with an emission permit system is determining a fair method for allocating quota entitlements. The initial allocations among participants would have a fundamental influence on the outcome. Serious concerns were raised about social distribution effects – whether initial entitlements would be given away or sold to the highest bidders through auctions. National pollution quotas and permit systems might also be negotiated globally, but the distribution controversy would only be more difficult among countries. An alternative idea was to arrange for businesses that enhance the environment to earn tradable conservation credits. These credits could be applied against those business' own pollution tax liability, sold to other polluters, or even swapped under special programs to reduce certain types of debt.

Redressing the Balance for Pollution beyond Ecosystem Carrying Capacity

Corporations responsible for pollution and other forms of degradation beyond environmental capacities could potentially arrange to offset the damage by financing environmental enhancement projects. With the aim of minimizing total costs, the investor has an incentive to seek or develop the technology for the most efficient remedial operation. An example mentioned during the workshop was the initiative taken recently by Applied Energy Services, a company that operates coal-fired electrical generating plants in the Eastern United States. In collaboration with CARE-USA and the government of Guatemala, this power utility undertook to offset the additional CO_2 emissions that one of its new plants would be releasing into the atmosphere by providing $2 million to finance the planting of 52 million trees in Guatemala. It was estimated that the growth of these trees would absorb about the same amount of CO_2 as the new plant was releasing.

A participant speculated that this approach, if expanded, could involve a quasi-market for CO_2 sinks, in which carbon emissions are exonerated with reforestation financing, or in which companies qualify for financial credits in return for emission reductions. Carbon emitters would seek areas of greatest biomass productivity and lowest labour costs, while various countries and regions would bid competitively for reforestation dollars. The regions with the lowest costs per unit carbon sink would attract the investments.

But remedial operations designed to maximize results with reference to one specific environmental aim (such as CO_2 absorption) may not fit a multiple-objective or long-term strategy for ecologically sustainable development. Fast-growing eucalyptus forests, for example, do not provide a valuable wood stock and degrade the quality of the soil, rendering it unusable for other types of vegetation or other purposes. Even in the case of the Applied Energy Systems initiative, a participant mentioned that many Guatemalans felt their country was being manoeuvred into 'abiding' by new and inappropriate environmental 'constraints' just so North Americans could continue to pollute. Some participants therefore suggested that offsetting project arrangements should be considered a valid redress only in the same country or jurisdiction where the initial damage occurred.[23] Others felt there are many circumstances for which such limitations should not apply, and the best approach would be to seek the lowest cost location and means to yield maximum efficiency.

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[23]For example, the Canadian *Policy for the Management of Fish Habitat* requires that when operations could damage fish habitat, the productivity of the habitat must first be maintained by avoiding or mitigating harm at or near the site directly affected. If this is impossible, a second option is to redress damage in equivalent terms at some other site. If this is also impossible, the policy finally provides for the possibility of negotiating some other way to counterbalance the damage for the fishing industry.

Resource and Environment Adjustments in Economic Accounting[24]

Introduction

The international collaborative process leading toward the development of integrated environmental and economic national accounts involves systematic re-examination of the conceptual foundations of core economic indicators. National income and GNP would be redefined or adjusted in the context of known ecological measures like resource degradation rates and damage to natural systems. This initiative served as an effective vehicle for deliberations at CEAC's workshop on indicators.

Before the workshop, participants reviewed a summary discussion document prepared by Peter Bartelmus, a co-author of the draft United Nations framework for a recommended System for Integrated Environmental and Economic Accounting (SEEA). Bartelmus summarized the logic and structure of integrated national accounting. Discussions among participants dealt principally with links between monetary and biophysical information; how to distinguish purely 'environmental' change from 'human-induced' effects; how to quantify induced changes in a biophysical accounting framework; and how to use the results in analysis and policy.

Economic accounting is a systematic framework for indicators used in economic analysis and policy. The *System of National Accounts* (SNA), published in 1968 by the United Nations Statistical Office (UNSO), continues to be the conceptual and organizational basis of national accounts in most countries of the world.[25] Since 1986, the entire SNA has been the focus of expert workshops through which the UN, OECD, and the World Bank have collaborated on developing a revised system to be published by the UN in early 1992. As part of these ongoing revisions, one of the expert workshop series held between 1986 and 1991 concentrated on ways to extend national accounts coverage to the resource and environmental changes induced by economic activity.

A draft of the supplementary handbook to the 1992 SNA, describing SEEA satellite national accounts in detail, was released for discussion in October 1990.[26] The phrase 'satellite accounts' implies that they expand national accounts methods to resource and environmental considerations "without disrupting the core system." This approach is the result of a compromise between those who would fundamentally change the SNA and others who would rather improve the basic 1968 framework. The SEEA handbook describes four basic elements of integrated environmental and economic satellite accounting:

1) disaggregation of environmental conservation activities from standard SNA flows and stocks;
2) biophysical accounting of material/energy balances to show the natural inputs to human processes, their transformation, and their return to the environment;
3) natural resource accounts that describe the part of the environment directly used and affected by human actions; and
4) hypothetical imputation of monetary values for the degradation of selected natural assets, to generate an adjusted net domestic product.

The SEEA handbook reflects 'work in progress'. In 1991, officials from UNSO and the World Bank have been experimentally implementing sections of this framework in collaboration with national statistics offices in Mexico and Papua New Guinea. In May 1991, a special conference of the International Association of Research in Income and Wealth focused on environmental and economic accounting.

Several important differences remain over whether or not, and if so, how, monetary and environmental information should connect within the context of national accounts. This round of

[24]The discussion paper for this round was "Environmentally Sound and Sustainable Development: A conceptual framework." P. Bartelmus. May 1990. To be released in *Structural Change and Economic Dynamics*, "Accounting for Sustainable Growth and Development." Peter Bartelmus (Chief, Environmental Statistics, United Nations Statistical Office) was the reference participant.

[25]United Nations Statistical Office. 1969. *A System of National Accounts*. New York: United Nations. Alternatively, Eastern European countries and the Soviet Union have used *Material Product Accounts*.

[26]United Nations Statistical Office. *SNA Handbook on Integrated Environmental and Economic Accounting – Preliminary Draft of Part I: General Concepts*. New York: UNSO. October 1990.

CEAC's workshop examined some key areas of current debate.

Valuation Conventions

Attempts to associate monetary values with things that are "never actually priced through the mill of supply and demand" are typically fraught with conceptual and practical problems. Working conventions can be formulated only on the basis of judgements about what aggregates would be 'good enough' for resolving major policy questions. Thus, when someone at the workshop asked how much the existing orthodox estimate of GNP could be expected to change if the proposed extended national accounts were implemented, the answer was that it depends on how users decide to make the adjustments. The new SNA draft will describe several approaches to incorporating resource and environmental changes into a general national accounting framework. It was emphasized that no 'correct' way of doing this can be developed except through a learn-by-doing process over several years.

The draft UN framework for extending the SNA for environment and resource considerations includes monetary values as they routinely occur. However, it disaggregates and improves the meaning of these values by referring to biophysical environmental data and standards that are not expressed monetarily. Thus, the new UN recommendations will describe environment and resource adjustments within a framework that extends, but is fully consistent with, established economic accounting principles.

A clarification was made that the UN system is unlike the preliminary work done by Robert Repetto and others at the World Resources Institute. That particular approach was not created under national accounting principles. Instead, it hypothetically determines direct monetary values for resource stocks; these amounts are then deducted from formal economic accounting aggregates like GDP. Repetto's approach does not alter the way GDP itself would be calculated, and adjustments related to environmental quality are not pursued.

There are many ways to adjust estimates of net national product (NNP), so it is important for *users* to decide what indicators will be useful.

The UNSO adopted the view that the resource and environment adjustments would be most helpful in evaluating alternative decisions (such as in relation to pollution taxes) if they are integrated fully into the national accounts that are the broad base for other policy choices.

Several participants agreed that monetary values can only be related to environmental effects if environmental changes are causally and quantitatively linked with subsequent changes in economic activity. It is impossible to put a market exchange value on all costs and benefits of the environment. But by measuring environmental change from the beginning to the end of a period of economic activity, the costs imposed by pollution and other repercussions can be assessed according to the costs of restoring the ecological *capacity* of the environment. Several participants were intrigued by the idea of valuing environmental degradation by the costs of restoring natural resources to their prior ecological capacity, where possible.

To give a numeric value to restoration costs, it is first essential to decide on standards for measuring and evaluating comparative ecosystem states. There is considerable international debate about how this should be done. A variety of measurement and estimation techniques, operational definitions of ecosystem constraints, and policy targets need to be experimentally applied. The learn-by-doing process will require much normative judgement along the way: Is this a good change? Who is responsible for damage? Is the expected outcome good enough? This broad *policy function* constitutes the crux of the interface between extended economic accounts and ecological processes. Participants wondered who would make these judgements.

One person cautioned that valuation of restoration costs must be considered an inherently backward-looking accounting procedure, and it may not provide much guidance for preventive actions. Decision-makers will also need to consider the costs of damage prevention, and compare these with restoration costs.

A Subsidy Concept to Incorporate Land Quality Changes

Economic accounts are currently compiled with no allowance for declines in land quality.[27] Development of descriptive indicators for the biophysical *states* of ecosystems is fairly well advanced, but our understanding of their vulnerability or fragility remains speculative. The new extensions proposed for the SNA would have supplementary tables of biophysical data on resources and cycling systems, connected with the monetary tables according to the cost of maintaining their quality. So many physical factors exist, such as soil, water, air, and weather, that a more comprehensive incorporation would be difficult or impossible. It was explained that we could assess physical soil quantity and quality and prepare supplementary tables that show the changes in natural assets. But these tables might be too erratic from year to year to provide a meaningful result. Nevertheless, an interesting suggestion for incorporating land quality changes in economic accounting arose with one participant's emphasis that sustainability is meaningless without contemplating "for how long" and "with what subsidies."

The point was illustrated with an example of farmland. As long as the self-regenerating capacity of the topsoil is maintained, then human use of the land is sustainable indefinitely. But if by relentless use the soil becomes dependent on chemical *subsidies* to maintain the rate of output we demand, this can only be sustainable for a limited period. Suppose there had been 10 inches of topsoil on a farm, now there are 5 inches, but productivity per hectare is the same. Productivity could be maintained only if fertilizers were used to substitute for the deteriorating soil quality. If this continues, the productivity of the land becomes increasingly dependent on external subsidies, rather than on the internal capacities of the living components of the soil. Financially, more and more of the farmer's operational costs go toward inputs that mask deterioration of the soil's intrinsic fertility. Eventually it becomes obvious that the soil cannot regenerate on its own; it is ecologically dead, and its only function is to hold roots in place for artificial farming methods.

Hence, an indicator of potential use in economic accounting would estimate *financial expenditures for inputs to compensate for soil degradation.*[28] This would generate a useful estimate of the direct financial importance of the soil's qualitative deterioration and dependence on physical subsidies. (There was not enough time during the workshop to expand on its application to economic accounting, but we can suppose that this value estimate of land *degradation* should be deducted from conventional value added.) On a larger scale, a participant suggested we could assess economic policies in general by the changes they bring about in the cost of compensating for environmental damage.

Natural versus Human-Induced Disasters: Implications for the Accounting Baseline

The data in biophysical accounts can be volatile over time. Judgement must be used to establish operational 'baseline' reference points against which to distinguish natural environmental transformations from changes directly induced by human activity. One question that came up in

[27]A technical note of explanation beyond the workshop discussion may be useful. It appears on the surface that a decline in the quality of land is reflected in national accounts because of lower land values and lower land productivity. But land is unlike manufactured capital in this respect. One workshop discussion paper noted an argument made by Alfred Marshall: "Now if the nation *as a whole* finds its stock of planing machines or ploughs inappropriately large or inappropriately small, it can redistribute its resources. It can obtain more of that in which it is deficient, while gradually lessening its stock of things as are superabundant; *but it cannot do that in regard to land*; it can cultivate its land more intensively, but it cannot get any more." (*Principles of Economics* 1920: 141) When the quality of manufactured capital deteriorates through use or obsolescence, this loss is directly captured in economic accounting estimates as *depreciation* because the money exchange value of such equipment declines. If replacements are temporarily scarce, any marginal rise in the unit price of manufactured capital is met by an increase in production and supply of new replacement equipment. In contrast, when the quality of land is degraded, what remains of healthy acreage becomes *more scarce*, because no new supply of good land is forthcoming (with some interesting exceptions). If, because of increasing scarcity, the rise in monetary value of healthy land exceeds the loss in monetary value of degraded land, a counter-intuitive net effect may show up in economic accounts. That is, the monetary value of all land will rise despite declining quality. This is especially easy to understand under circumstances of a rising population. This anomaly is further exaggerated if the declining quality of the land occurs as a direct result of intensive farm practices that boost its short-term productivity, because the existing economic accounting conventions portray this as real economic growth.

[28]Someone pointed out that different economic circumstances among countries influence the degree to which soil degradation can be compensated with artificial inputs. In North America and Europe, farm credit and subsidies have helped finance the high input of chemicals and machinery that mask soil deterioration. In most Asian, African, and Latin American countries, few farmers have the money to maintain a steady flow of inputs that can compensate for loss of 'free' soil fertility. As a result, damaging practices are more immediately evident in declines in the health and well-being of people.

discussions about valuation was: How should natural disasters be treated in extended economic accounts? In the new SNA, natural disasters would show up in balance sheet accounts (resource and environment stocks), but would not be included in income accounts (flows). Thus, certain types of sudden shocks that occur in monitoring data might be excluded from supplementary tables for the income estimate, such as the costs of restoration activity following natural disasters. But shocks caused by human activity, like the cost of cleaning up the Exxon oil spill in Alaska, would now appear in the income tables, subtracted as intermediate expenditures from gross revenues. (Existing national accounts treat clean-up and restoration expenditures as *contributing* to value added.)

Still, several participants felt there should be some way of recording natural catastrophes in the flow accounts. The new SNA should be extended not only to include human effects on the environment, but also to better represent environmental effects on humans. Indeed, human activity appears to be increasingly responsible for some aspects of 'natural' disasters, such as those caused by more extreme fluctuations in the weather. Generally, the economic effects of at least certain types of disasters provide meaningful evidence of the vulnerability of the economic base and its influence on ecosystems. Droughts in the Canadian prairies, for example, can be realistically considered a normal part of agriculture in that ecological region, as well as a function of both the local and general economic structures that have been established. As such, these droughts should not be overlooked in the supplementary income adjustments as natural disasters.

Some Caveats for Users

The Sustainability Notion

Indicators that help identify sustainable development are in great demand. But an estimate of net national income from supplementary accounts adjusted for resource and environment considerations should *not* be referred to as 'sustainable income'. Many further aspects to sound development, such as equity and demographics, also determine sustainability.

Nature of the Estimates

Users of economic accounting aggregates that are adjusted for environment and resource considerations should remember that the valuation system used is hypothetical, even if it is realistic. The UN framework will recommend assessing the net value of preventing environmental degradation. This is done by estimating potential restoration costs required to achieve the level of environmental quality at the beginning of the accounting period, or a level specified by official environmental standards. This approach takes national accounting of production beyond the established practices of counting and estimating activities that have already occurred to the projection of *future* potential restoration costs associated with those activities.[29]

Limitations

The main purpose of adjusting the national accounts for resource and environment considerations is to alert decision-makers to potential problems in structural economic trends. Like any accounting system, the focus of measurement is on the difference between two or more accounting periods, rather than measuring progress toward particular states. Consequently, one participant explained that no matter how the national accounts are changed, they will not help decision-makers anticipate or prevent the economic consequences of surprises due to flips in ecosystem equilibrium, or other more specific hazards and risks. Furthermore, the adjusted income accounting method would not reflect improved environmental quality. If changes occur because of better urban air quality or new resource discoveries, these would show up as environmental production in the stock and flow tables of natural resource accounts without directly influencing the economic income and expenditure accounts related to human production.

Ethical and Political Aspects

The adjustments are not intended to define moral concepts of equity over such things as species extinction. Each particular society must establish its own set of values. Each government must make policy choices based on these social ethics. As with any sort of information, environmentally

[29]Ecosystem modelling will therefore play an increasingly important role in determining economic indicators and, through their use, in macroeconomic analysis and policy. Systematic estimates will eventually require an economic model integrated *within* an ecosystem model. This leads to *institutional* questions about the proper placement of in-house capability for ecological modelling in government, as well as *ideological* questions of what paradigm will be accepted as the standard underlying official judgement and interpretation.

adjusted indicators and indices can be used or misused politically. Valuation procedures can be easily skewed to preconceived ends.[30]

Process of Implementation

There is no process yet in place for experimentally implementing the adjusted economic accounts framework. There is not even agreement on the general shape of such a process. Some pilot studies are beginning in a few countries and the preliminary handbooks for implementation may be ready for 1992, but it will be several years before the world accepts these new forms of national accounting and uses the data to make daily decisions. Parts of the new draft framework are being tested in two countries. A few other countries, including Canada, are being recruited. As experience is gained and the results prove helpful, there will be greater incentive for decision-makers to use the fully integrated system. But this is still some years away, and it may be 15 or 20 years before comparable time series data are available from several countries. Several participants felt that the implementation process should be accelerated.

[30]This is not peculiar to the environmental adjustment of economic accounts, a point made clear by a pioneer of national accounting, Simon Kuznets. He wrote: "For those not intimately acquainted with this type of work it is difficult to realize the degree to which estimates of national income have been and must be affected by implicit or explicit value judgements . . . The apparent relative unanimity produced by empirical writings on national income is due largely to the estimators' unconscious acceptance of one social philosophy and their natural reluctance to face such fundamental issues as would reveal that estimates are conditioned by controversial criteria." (Kuznets, S. 1941. *National Income and its Composition, 1919-1938*. Vol 1. New York: National Bureau of Economic Research. p. 5.)

4 Closing Comments

Core Issues

Regenerative Capacity[31]

A core working group on ecosystem regenerative capacity offered the following advice to Canada's Minister of the Environment:

1) The global life support system is about to collapse.
2) Canada is contributing to global climate instability by devastating its forests.
3) Canada is contributing to the destruction of natural air filtration by draining its wetlands.

The working group recommended:

- **a policy**: Canada should strive toward ecologically sound policy at global, continental, and domestic levels.
- **a program**: Canada should invest in ecosystem science and improve the wider communication, comprehension, and application of this knowledge at all levels.
- **a project**: Canada should assemble a series of technical workshop sessions among senior economists and ecologists to identify and develop policy applications for critical ecosystem indicators and constraints.

During this session, participants tried to identify the general characteristics and focus of a few indicators that could reflect enough of the essentials to be used for macro-level policy guidance. One participant raised this point: indicators that focus on 'regenerative' capacity seem inherently retrogressive because this word appears to imply the reinstatement of identical conditions after an injury. Instead, he suggested, "what we really want to protect is the capacity of ecosystems to carry on organizing themselves." Many found this to be a useful distinction. Participants also concurred with the wider professional scientific judgement that many societies are on, and in some cases beyond, the threshold of catastrophic losses to the self-organizing capacity of major ecosystems.

It was agreed that ESD indicators of practical use for policy have the following characteristics:

- *ESD indicators emanate from a vision of the economy as a subsystem of the ecosphere.* Thus, a key strategic policy matter for which indicators are needed is how physically 'big' the economy is, can be, and should be, in relation to the larger system. Members noted that this was not an emphasis on exhaustible resource limits (like the Club of Rome report), but rather on the dynamic operational requirements of living ecosystems.
- *ESD indicators reveal system trends and oscillations in relation to critical thresholds, constraints, and optimal states.* The strategic policy focus requires indicators that reflect the *changing states of ecosystems*, rather than the input-output circumstances at any particular time. The Great Lakes, for example, demonstrate increasing oscillation. Ecosystems, and communities within them, frequently experience wider oscillation as they break down, so this can be a strong indication that an ecosystem is facing pressures that have pushed it beyond critical thresholds. Beyond generalities, however, no adequate indicators currently exist to reflect ecosystem state oscillation. Yet they would be useful to policy because *average* measurements could remain the same even as oscillations increase, and thus would fail to communicate a warning. On the other hand, if indicators do not allow for natural ecosystem crests and troughs, these essential and transient states might be perceived as crises to be counteracted. If they are 'successfully' suppressed, natural cycles of rejuvenation may be blocked. If moves to suppress natural crests and troughs combine with the ecosystem's own counteractive responses, human interference may even exacerbate the extremes.
- *There is no single focus for ESD indicators, but different types of information are arranged to answer transdisciplinary questions.* Key factors to be monitored will be qualitatively very different: *physical, chemical, biological, social,* etc. But links can be useful, such as geographically coding economic data by biomes, drainage basins, and ecozones. It was also mentioned that *global* ESD indicators have correspond-

[31] This section is based on a core group session on 27 July, using summary discussion points prepared by rapporteur Brian Hull, flipcharts from session facilitator Rodger Schwass, and some ideas from other workshop discussions. This group addressed the following: Is maintaining the regenerative capacity of ecosystems an appropriate concept for imposing constraints on economic growth?; Identify three key indicators of regenerative capacity.; and What would you tell the minister concerning indicators and this issue?

ing *continental*, *country*, and *local area* correlates, even though the meaning of subglobal-level indicators varies by region, country, and local area.

- A stitch in time saves nine: *ESD indicators have a critical time factor.* Rough 'n ready measures are problematic, but spending too much time fine tuning will make ESD indicators of little consequence to decisions.

Participants suggested some specific indicators that are crucial for guiding ESD policy. These are listed in the following table on major ecosphere indicators.

Ethics, Equity, and Social Welfare[32]

ESD indicators should be understood as *information framed according to ethical precepts.* A sound conceptual framework for ESD indicators is one that facilitates the use of available information for behavioural decisions involving value judgements. Thus, participants stated that human beings have intrinsic value in both individual and community dimensions, and nature itself has intrinsic value in both species and ecosystem dimensions. They believed judgement should seek to optimize sustainable opportunities in all these aspects.

Ethics are about human conduct, so they are fundamentally anthropocentric. But it was emphasized that an ethic need not be anthropomorphic, which implies subjecting everything else to human forms and designs. Responsible stewardship, respecting ecological and cultural equity and welfare, has direct implications for both the daily and strategic management of human affairs. The judgements we make influence the future of ecosystems and their constituents, including human beings. Thus, it was agreed that sustainability is more than a biophysical concept. It also involves socioeconomic equity and well-being in body and mind. Understanding the link between social and environmental indicators is vital.

Participants suggested two ways that ethics are related to ESD indicators. First, ethics give substance to the overall information framework. To illustrate, *the proportion of protected land* is just a bit of information. But our judgement about its meaning (what does this indicate?) is an ethical matter. Second, specific ESD indicators are shaped to address particular human concerns about equity and social welfare in relation to regions, genders, social groups and nationalities (aboriginal nations), generations, and other facets. Indicators mentioned as appropriate for monitoring performance fall within the following two general categories.

1) **Social harmony**:
   - individual and collective self-reliance balanced with participation in social life and decision-making; and
   - diversity, representation, and openness.

2) **Distributional equity**:
   - *humans with the environment* –
     (a) land, water, energy, and other resources;
     (b) natural experience (for example, the proportion of urban land in parks); and
     (c) health (for example, 'disability-free' life expectancy).
   - *humans with each other* –
     (a) income, and opportunities for rewarding employment; and
     (b) knowledge and opportunities to learn.

Getting the Prices Right[33]

It is well established that many significant environmental costs are not presently reflected in the market exchange prices of commodities. Because environmental goods and services are not exchanged for money, participants agreed there is no simple solution to how commodity prices should be 'corrected' for induced environmental change.

[32]This section is based on a core group session on 27 July, using summary discussion points prepared by rapporteur Paul Rump, flipcharts from session facilitator John Robinson, and some ideas from other workshop discussions. This group addressed the following: Propose two or three indicators appropriate for monitoring intra- and inter-species *ethics, equity*, and *social welfare*; and What would you tell the Minister of the Environment concerning indicators and this issue?

[33]This section is based on a core group session on 27 July, using summary discussion points prepared by rapporteur Munir Sheikh, flipcharts from session facilitator David Conklin, and some ideas from other workshop discussions. This group addressed the following: Getting the prices right: How can the price system be adjusted to better accommodate what we now know about the supply and demand of ecological goods and services?; Propose for further development a short list of workable indicators for use in regulation, taxation, tradable permits, credits, etc.; and What would you tell the Minister of the Environment concerning indicators and this issue?

Major Ecosphere Indicators

Primary Production Indicators
Factors limiting photosynthetic capacity that were discussed included: biologically active surface area, air, water, minerals, gene pool, and solar radiation.

Distributional aspects of ecosystem integrity would consider the *proportion of total photosynthesis output that is directly or indirectly used, or otherwise preempted, by individual species* – in particular, *Homo sapiens*. This is closely related to trophic level measures – the more trophic levels in a given environment, the more developed the ecosystem.[34]

Atmospheric Function Indicators
Air filtration, oxygen and carbon dioxide cycling, and climate regulation,[35] are three critical atmospheric functions of the biosphere discussed. The principal indicators suggested to reveal the capacity of the biosphere to perform these functions is straightforward: the *area of wetlands* and the *area of forests*.

Constituent Indicators
Species diversity, and the *genetic diversity within species*, represents a vast and irreplaceable inheritance of evolving biological compounds, structures, systems, and processes.

A few *key species* govern the temporal and spatial characteristics of each ecosystem. The loss of key species will disrupt several other species, or possibly the entire ecosystem.

The condition of *charismatic species* like beluga whales, peregrine falcons, and the great blue heron can catch and focus public attention, so information about them rather than other species has a stronger influence on policy.

The condition of some easily studied *indicator species* reveals much about the rest of their environment. Some suggested that the human being is a useful indicator species because certain health statistics are excellent reflections of general environmental quality, and because more information exists about us than about any other species. Indicators mentioned were: incidence of 'total human system failure syndrome' and other allergy-related problems; incidence of immune system deficiencies;[36] and infant mortality rate.

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[34]A participant referred to a recent study estimating that 40 per cent of net primary production of terrestrial photosynthesis is used or preempted (i.e., including 'paving over' the capacity for it to occur) by human activity. (Net primary production from photosynthesis is that portion of carbon fixed by plants that is not respired away by maintenance metabolism, hence it results in the increase of plant biomass.) This may be taken as a rough index of how big the human subsystem is in relationship to the total system. One person cautioned that our real focus should be on ecosystem dynamics, but the proportion of photosynthesis taken by humans is a valuable measure nonetheless. Indeed, one aspect of system integrity is the proportion of photosynthesis acquired by each species, or particular group of species. For example, in the Great Lakes the ratio of benthic fish over pelagic fish has declined since the mid-1940s, plateauing briefly in the late 1940s, and declining steadily to the present. Calculating proportions is laborious, but two simpler indicators were suggested that reveal much the same thing. One is the number of trophic levels. For example, Chesapeake Bay has six trophic levels and the Baltic Sea has seven. The more trophic levels, the more 'organized' the system. A loss of system integrity is revealed by a reduction in the number of trophic levels. A participant suggested that a second, more 'rough 'n ready' indicator might be "the ratio of big critters over small," assuming it takes a critical number of small fish to support each large fish over a known period of time.

[35]A participant discussed the results of some recent research at the United States National Oceanographic and Atmospheric Administration, which suggests that the amount of energy captured by vegetation that is applied to 'pumping water' seems to be an even more critical factor than how much energy the vegetation can capture in its own biomass. Major global convection currents are anchored in the tropical and boreal forests. These currents depend on the forests and are key to the 'air conditioning' of the planet.

[36]Total human system failures from allergies are occurring more often and are a function of environmental stress. This is an indicator of human system failure. There are also several manifestations of environmentally induced weakening of the human immune system.

Nevertheless, participants felt that practical adjustments can be made to market systems by trial and error using a variety of information and instruments. These could bring environmental costs to bear on actual market prices. If appropriate adjustments can be estimated, any wedge between *'full-cost' and 'actual' prices provides a financial* appraisal of the 'marginal social damage' to the environment. This amount may be considered equal to the optimal additional tax that should be applied to pollution (and other forms of degradation considered in the adjustments). If such a tax was implemented, relative commodity exchange prices would better reflect their respective environmental efficiencies. The corrected price structure would affect business and household decisions, and result in environmentally sound changes to the economy.

Participants suggested that the process of adjusting prices for induced environmental degradation requires two distinct indicator sets.

Biophysical Indicators of Environmental Quality

Biophysical information such as emissions, loadings, ambient conditions, and rates of resource depletion, must be related to specified targets and timetables if they are to serve as indicators. The policy requirement of such indicators is to monitor the *process of moving toward or away from targets.* Some targets may be specific milestones (the proportion of land in parks, for example), while others will be expressed in terms of a direction of change (reduction in CO_2 emissions). Interpreting changes to all such indicators collectively requires a complex set of judgements. But if the purpose is to affect economic behaviour, one way to approach cumulative analysis is to adapt economic indicators for induced changes in the biophysical indicators.

National Economic Indicators

The development of integrated economic indicators must begin with an understanding of the causal links between sectoral economic activity and induced biophysical changes affecting ecosystem integrity. Market analysis can be used to estimate the financial costs of reaching the relevant targets, and functional indicators can be generated to help policy-makers compare estimated financial expenditures on ecosystem conservation with plausible financial costs of ecosystem degradation and depletion. The overall policy relevance of making these adjustments can be assessed by comparing the conventional aggregates with the adjusted figures. Disaggregated indicators, such as the likely distribution of ecosystem conservation expenditures among sectors, groups, or regions, may be even more important to decision-making. Some participants suggested that 'price-equivalent' effects of different instruments could be used to evaluate their comparative effects on the different economic sectors.

More on the Natural Capital Concept[37]

The concept of 'maintaining capital intact' does *not* imply the static preservation of a constant stock. This is well understood for machines: it is by sustaining the flow of useful services from these assets that their value may be preserved. Built capital is the product of human knowledge applied to resources from the biophysical world. Characterizing the ecosphere as natural capital is fairly informal and artificial, but it does help to extend the idea that to keep natural capital intact means *sustaining the ability of dynamic ecosystems to supply services.* This notion of ecosystems 'at our service' might strike some as an excessively anthropocentric perspective. However, it was suggested as a pragmatic abstraction during workshop discussions, since many participants agreed it is because of the utter failure of conventional economists to take account of the need to maintain essential ecosystem services that decisions continue to be made that lead to serious ecosystem degradation.

In the workshop discussion, human capital was classified into physical and intellectual assets, and natural capital into renewable and depletable wealth. Again it was emphasized that the distinctions were artificial, and not even mutually exclusive. For physical and intellectual assets, design features of built capital comprise an intrinsically intellectual component. For renewable and depletable wealth, species and ecosystems are 'renewable', but can be rendered 'depletable' by overgrazing, steep

[37]This section is based on a core group session on 27 July, using summary discussion points prepared by rapporteur Mike Kelly, notes and flipcharts from session facilitator Erik Haites, and some ideas from other workshop discussions. This group addressed the following: Does it help or hinder our understanding of 'development' to conceptualize environment as capital?; Consider (at least): technological and structural changes, complementarity and substitutability, and money as a numeraire; and What would you tell the Minister of the Environment about indicators and this issue?

slope clear-cutting, acid rain effects on aquatic life, etc. And 'depletable' resources are partially 'renewable' because they can be reused and recycled.

Keeping all these caveats in mind, it was suggested that a framework for ESD indicators on capital should record flows of services and changes in stocks from each of the four categories (built, intellectual, renewable, and depletable). Developing aggregate measures across the categories is not a requirement, but aggregations within each would be useful. Information should appear in the units most appropriate to what is being measured, which means not exclusively in monetary terms. Where it is difficult to attribute credible prices, this should not be attempted. Generally, it was expected that some information would be comparable across categories, but other measures will be specific to each. It may be more useful to know the capacity of land to produce ecological services in a physical sense, rather than suppose a hypothetical value for the current and future production from that land. The next several generations may not require or prefer the same set of flows of ecosystem services as are drawn on today, so even if relative substitution prices are estimated, these valuations might not hold through time.

Technological and ecosystem change will shift the relative proportions and absolute dimensions in which human beings draw services from each of these categories. To the extent that our economy becomes more knowledge driven, there should be greater emphasis on human intellectual capital, and a relatively lower *per capita* requirement for physical production and the natural resource base that supports it. At the same time, a greater population leads to an increased demand for physical production. Increased numbers of people *may* represent an increase in certain forms of intellectual capital, but this is less certain. If growing populations diminish the opportunity for people to lead meaningful lives, the knowledge base could deteriorate because of decreasing education, poor diet, psychological stresses from overcrowding, and disease. There could be an absolute or a relative loss of services from intellectual capital, despite the greater numbers, just when it is needed most.

Humans do not know enough about ecosystems and how the critical components work together to manage them, so the keyword is 'prudence'. If human economic systems are to be sustainable, we must err on the side of caution. Stewardship requires knowledge about the characteristics of stocks and dynamics of flows in natural capital, and of the human causal factors changing ecosystems.

Participants suggested two levels of policy-relevant indicators of capital. A primary set of indicators would track service flows from each category of capital, and the substitution of service flows from one category for those of another. A secondary set of indicators would reflect constraints on changes within particular categories, related to productivity, capacity, resiliency, irreversibility, and vulnerability. The indicators would be used as inputs to policies designed to 'get the prices right' in the market system. By implementing 'full-cost accounting' so that the full environmental services cost shows up in the price system, efficiency-driven decision criteria of millions of consumers and investment decision-makers would lead to innovation that substitutes knowledge for physical resources. As a resource diminishes or is constrained, it need not become more expensive, depending on the success of the search for less expensive or less harmful substitutes.

It was suggested that the commercial sector seems more flexible in responding to changes in the overall environment. Why? The private sector has greater flexibility – as a key component of survival – to ever-changing supply and demand prices, consumer tastes, interest rates, taxes, and a dispersed information system. It was proposed that governments could learn about the value of flexibility and rapid adaptation from the private sector.

Using Worst-Case Scenario Analysis[38]

Worst case scenarios are the projected outcomes of a plausible series of events. They could be viewed as the 'most believable bad outcomes'.

Analyzing worst-case scenarios is useful when much is at stake, or when the probability of future events cannot be estimated. Issues that affect the 'global commons' usually involve substantial

[38]This section blends summary points prepared by Jack Ruitenbeek from a core group discussion with relevant issues in notes by four other rapporteurs on decision theory. The core group addressed the following: How can worst-case scenarios form the basis upon which indicators are derived?; What roles do risk assessment, risk management, and risk communication play in deriving indicators?; and What would you tell the Minister of the Environment concerning this issue?

uncertainty and very high stakes. Greater cognizance of the full range and sensitivity of possible outcomes, from the most pessimistic scenarios to potential best-case outcomes, can motivate cautionary change to prevent the more pessimistic outcomes from ever happening.

The scenarios must reflect the connections among current political, economic, and ecosystem trends and events. But depicting worst-case scenarios also involves value judgements about the realism and appropriateness of assumptions about future events, and about the boundaries of what is considered 'unacceptably bad'.[39] An important comment was made that worst-case scenarios should also explore equity implications by addressing who or what is at risk over what time period. One participant described how this type of scenario analysis has traditionally concentrated on determining what the worst possible effects would be on short-term human health and welfare. But participants believed it would be valuable to consider the worst possible effects of policies and actions on *medium- and long-term* ecosystem health and welfare. Decisions must be made about what indicators analysts want to observe, and what definitions to apply.

Some participants questioned whether worst-case scenarios have a place in realistic decision-making when we have only one Earth. Human society and ecosystems can absorb limited risks, but contemplating global worst-case scenarios seems to contemplate placing the entire system at risk. Are worst-case scenarios ('gambler's ruin' type analyses) sensible in decision-making intended for sustainable development? Ten years ago, using worst-case scenarios was seen as alarmist, and environmentalists are still often perceived that way. But economists are moving in this direction more and more, as they realize the enormous cost of repairing environmental mistakes – if repair is even possible. The logistics, complications, and costs of structural changes to restore the ozone layer, or to adapt to the consequences of global warming, are presumably so severe that it is prudent to guard against further degradation. An important study of future scenarios for Western Europe concluded that worsening environmental problems would become crises under *all scenarios* except the 'environmentally friendly' path. The Netherlands and West Germany are now developing policies to prevent or buffer foreseeable worst-case scenarios. Worst-case scenarios and indicators have also been used in arriving at decisions about the Montreal protocol on CFCs.

The reasons for imprecision and uncertainty in scenario approximations should be understood by decision-makers and the public if they are to appreciate the quality and character of information that such analysis provides. Otherwise, they may just question its credibility when events do not unfold as projected.

Participants discussed different reasons for uncertainty. Uncertainty is inherent in the *dynamics of complex systems*, so indicators generated by hypothetically modelling the future must always be accompanied with some scepticism. Other indicators are obtained by actually monitoring events as they happen or after the fact. However, uncertainty in monitored information is also caused by *measurement problems*, such that indicators may not truly reflect actual characteristics and events, or properly represent accounting identities that depend on particular theories of causal relationships.

It is important to ask what indicator sets can best communicate the sort of insight gained through worst-case scenario analysis to the range of interested groups in society. Generally, it is useful to link economic indicators to the state of the environment, and then project how current policies could potentially affect future conditions. But understanding scenario indicators depends on whether decision-makers understand what *questions* are being asked, under what *assumptions*, over what *time periods*, and within what *degrees of precision*.

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[39] Judgements about what is realistic, appropriate, and desirable each have a part in determining the overall design of scenario analysis. To illustrate, while there might be realistic speculation of an overwhelming annihilation of human populations within 20 years, such an eventuality may not be an appropriate assumption in worst-case scenarios designed for the analysis of sustainable human activity and ecosystems. In another context, one person's *worst case* may be another person's *best case*. Consider forecasts of a major rise in oil prices. In the short term, consumers like low prices and producers like high prices. But since higher prices over a longer period of time motivate oil conservation and create market conditions for the development of alternative sources of energy, consumers may prefer higher prices and oil producers may not. Political judgement is often a key ingredient in scenario development.

Appendix A: Workshop Participants

Workshop: 25-27 July 1990
The Fountain Room, National Arts Centre, Ottawa

Environment Canada

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State of Environment
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Department of Finance

Michael Francino
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Economic Development Policy

Statistics Canada

Stewart Wells
Assistant Chief Statistician
National Accounts

Kirk Hamilton
Manager
Environment and
Natural Resource Statistics

Economic Council of Canada

Caroline Pestieau
Deputy Chair

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Arthur R. Marshall Chair
University of Florida

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Carleton University

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David Rapport
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Jean-Pièrre Revéret
Université du Québec à Montréal

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Research Council

Phil Ross
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Organization for Economic Cooperation and
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Ruitenbeek Resource Consulting

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BOB PAGE
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PETER CHAPMAN
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STAN ROWE
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VEENA HALLIWELL
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CEAC Staff

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ANNE MARIE CREVIER
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Workshop Coordinator

JOSEPH R. POTVIN
Economist
CEAC, on secondment from the Policy Directorate,
Environment Canada

Appendix B: Workshop Agenda

Workshop: 25-27 July 1990
The Fountain Room, National Arts Centre, Ottawa

25 July	
p.m.	
7:00 - 9:00	Informal reception and introductions. *Burgundy Room, Mezzanine Level, Chateau Laurier Hotel.* One-minute statement by each participant. Focus: *What are some **specific conceptual challenges** we face in formulating the sustainable development indicators called for at the 1989 G7 Summit?*
26 July	
a.m.	
8:30 - 9:00	Explanation of workshop methodology, administrative matters, and remaining opening comments (for those not present on previous evening).
9:00 - 11:00	Half-hour simultaneous rotational presentations and discussions by authors of **DS 1**, **2**, and **3**, with each of three groups.
11:00 - 12:00	Group discussions on the meaning and use of information about *ecological integrity* and *exhaustible assets* in the context of three quantitative applications: • adjustment or extension of economic accounting; • resource and environmental provisions in taxation; and • economic assessment of environmental investment projects. (*See attached note on the structure of the group discussions.*)
p.m.	
12:00 - 1:00	Catered lunch.
1:00 - 3:00	Group discussions, continued.
3:15 - 4:45	Identifying and scoping *core issues* to formulate integrated and complementary analytical indicators of ecological and economic performance and sustainability. Topics of most interest to participants will be the focus of a more complete examination the following day in self-selected groups.
6:00 - 7:00	Meeting of facilitators, authors, rapporteurs, and coordinators.
7:00 - 10:00	Dinner: *Courtyard Restaurant, Byward Market, Ottawa.*
27 July	
a.m.	
7:00 - 8:00	Working breakfast for facilitators, authors, rapporteurs, and coordinators. *Courtyard Restaurant, Byward Market, Ottawa.* Discussion and agreement upon leading discussion questions for each of the *core issues* identified.
8:30 - 9:00	Overview and suggestions for changes on the day's planned events.
9:00 - 11:00	Discussion of *core issues* in the overall framing of sustainable development indicators, and suggestions for action.
11:00 - 12:00	Rapporteurs' reports from each group.
p.m.	
12:00 - 1:00	Catered lunch.
1:30 - 3:00	Two-minute wrap-up statement by each participant. Final observations and input. Next steps?

Structure of Group Discussions on ESD Indicator Applications in Investment, Taxation, and National Accounting (26 July)

Participants will be assembled into three groups of ten to discuss practical links between the theory and application of alternative understandings derived from economics and ecology. Each group will be assigned its own facilitator and a rapporteur.

Three quantitative applications are proposed for discussion. These applications will rotate: each group will be asked to consider each for about one hour:

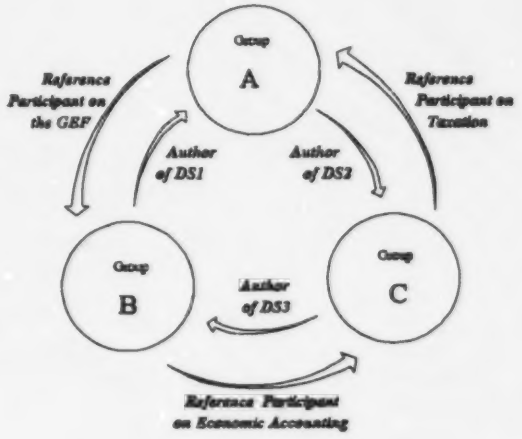
- **Adjustment or extension of economic accounting**: Excerpt about supplementary tables to *1991 System of National Accounts*. Bartelmus, P. 1990. *Environmentally Sound and Sustainable Development: A conceptual framework* (discussion draft).
- **Resource and environmental provisions in taxation**: Oates, W. 1988. Taxing pollution: An idea whose time has come? *Resources*.
- **Economic assessment of environmental investment projects**: Excerpt from discussion paper on a proposed Global Environment Facility. The World Bank.

All excerpts and associated notes will be provided at least a week before the workshop. Participants and facilitators are asked to focus on *the meaning and use of information about ecological integrity and exhaustible assets in the context of the three quantitative applications*. The focus is not whether the specific instruments and structures should or should not be active policy options of the Canadian government or other institutions. The intention is to explore micro and macro links from theory to measurement and analysis, without looking at policy or subsequent action.

Because of the diversity of experience among participants, there will be different degrees of familiarity with these issues. Therefore, one key reference person with specific expertise on each of the topics will sit as an active participant with each group to provide guidance and background while the particular topic is considered. The reference persons will rotate to different groups each hour. The three authors of the *Delineation Studies* will play a surveying role in the workshop. They will determine overall links and contradictions as they occur throughout the sessions. With each change of topic on the 26th, the authors will rotate among the groups, and also among the reference persons. This will also give authors useful insight for finalizing their delineation studies for the published report of proceedings. At the end of the day on 26 July, the authors will meet on their own to compare observations, and provide independent advice to the group facilitators and CEAC organizers, in preparation for workshop discussions of *core issues* on 27 July.

The proposed timetable is:

11:00	-	12:00	First group discussion
12:00	-	1:00	Catered lunch
1:00	-	2:00	Second group discussion
2:00	-	3:00	Third group discussion
3:00	-	3:15	Coffee break



Appendix C: List of CEAC Publications

(1) An Environmental Impact Assessment Process for Canada, February 1974. (out of print).

(2) An Environmental Ethic – Its Formulation and Implications, by N.H. Morse, January 1975. (out of print).

(3) Harmony and Disorder in the Canadian Environment, by P. Danserau, 1975. (English out of print).

(4) Towards an Environmental Ethic, by D.A. Chant, March 1977. (out of print).

(5) Environmental Aspects of Nuclear Power Development in Canada, by H.E. Duckworth, H.W. Porter and J.S. Rogers, 1977. (out of print).

(6) Report of the Second Joint Meeting of Environmental Advisory Councils, May 1977, Fort San, Saskatchewan. (Produced in collaboration with the Saskatchewan Environmental Advisory Council, March 1978).

(7) The Management of Estuarine Resources in Canada, by I.K. Fox and J.P. Nowlan, March 1978.

(8) Report of the First and Second Meetings of Public Interest Groups with the Canadian Environmental Advisory Council, May 1978.

(9) Ecotoxicity: Responsibilities an Opportunities, by R.H. Hall and D.A. Chant, August 1979.

(10) Report of a meeting between the Public Interest Groups and the Canadian Environmental Advisory Council, May 26-27, 1980. Published in 1981.

(11) A New Approach to Pest Control in Canada, by R.H. Hall, July 1981.

(12) Wildlife Conservation Issues in Northern Canada, by I. McTaggart-Cowan, October 1981.

(13) Water Management Problems in the Third World: Lessons for Canada, by P.F.M. McLoughlin, March 1983.

(14) Terms of Reference, March 1984.

(15) Report of the Eight Assembly of Environment Councils of Canada, May 1984.

(16) Selected Papers from Assemblies of the Environment Councils of Canada, 1975-1980, March 1985.

(17) Sustainability of Farmed Lands: Current Trends and Thinking, by C.F. Bentley and L.A. Leskiw, March 1985.

(18) Examining Environment-Economy Linkages, by R.A. Knowles, 1986.

(19) Freer Trade and the Environment, May 1986.

(20) Enforcement Practices of Environment Canada, by L. Giroux, June 1985. Published January 1987.

(21) Review of the Proposed Environmental Protection Act, March 1987.

(22) Canada and Sustainable Development. A Commentary on Our Common Future, the Report of the World Commission on Environment and Development and its Implications for Canada, December 1987.

(23) Preparing for the 1990's: Environmental Assessment, an Integral Part of Decision Making, February 1988.

(24) Listing Toxics Under CEPA – Is the Chemistry Right?, May 1988.

(25) On the Role of Environmental Councils – In Relation to the Canadian Environmental Advisory Council, by Dr. P. Bird, May 1989.

(26) PCB's – A Burning Issue, February 1989.

(27) Land Use Planning and Sustainable Development in Canada, by Nigel Richardson, May 1989.

(28) Annual Review of Activities 1989-90. (Previous Reviews available on request).